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BGP YANG Model for Service Provider Networks

Abstract

This document defines a YANG data model for configuring and managing BGP, including protocol, policy, and operational aspects, such as RIB, based on data center, carrier, and content provider operational requirements.

Status of This Memo

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1. Introduction

This document describes a [YANG 1.1](#) [RFC7950] data model for the [BGP-4](#) [RFC4271] protocol, including various protocol extensions, policy configuration, as well as defining key operational state data, including a Routing Information Base (RIB). The model is intended to be vendor-neutral, in order to allow operators to manage BGP configuration in heterogeneous environments with routers supplied by multiple vendors. The model is also intended to be readily mapped to existing implementations to facilitate support from as large a set of routing hardware and software vendors as possible. This module does not support previous versions of BGP, and cannot support establishing and maintaining state information of neighbors with previous versions of BGP.

1.1. Goals and approach

The model covers the base BGP features that are deployed across major implementations and the common BGP configurations in use across a number of operator network deployments. In particular, this model attempts to cover BGP features defined in [BGP](#) [RFC4271], [BGP Communities Attribute](#) [RFC1997], [BGP Extended Communities Attributes](#) [RFC4360], [BGP Large Communities Attributes](#) [RFC8092], [BGP Route Reflection](#) [RFC4456], [Multiprotocol Extensions for BGP-4](#) [RFC4760], [Autonomous System Confederations for BGP](#) [RFC5065], [BGP Route Flap Damping](#) [RFC2439], [Graceful Restart Mechanism for BGP](#) [RFC4724], [BGP Prefix Origin Validation](#) [RFC6811], and [Advertisement of Multiple Paths in BGP](#) [RFC7911]. It attempts to make the model extensible by using identities for well known standard community types, and the use of "raw" string to support new and experimental type definitions.

Along with configuration of base BGP features, this model also addresses policy configuration, by providing "hooks" for applying policies, and also defining BGP-specific policy features. The BGP policy features are intended to be used with the general routing policy model defined in [A YANG Data Model for Routing Policy Management](#) [RFC9067].

The model conforms to the [NMDA](#) [RFC8342] architecture. It has support for securing BGP sessions using [TCP-AO](#) [RFC5925] or TCP-MD5, and for configuring [Bidirectional Forward Detection \(BFD\)](#) [RFC5880] for fast next hop liveness checking.

For the base BGP features, the focus of the model described in this document is on providing configuration and operational state information relating to:

- *The global BGP instance, and neighbors whose configuration is specified individually, or templated with the use of peer-groups.
- *The address families that are supported by peers, and the global configuration which relates to them.
- *The policy configuration "hooks" and BGP-specific policy features that relate to a neighbor - controlling the import and export of NLRIs.
- *BGP RIB contents.

As mentioned earlier, any configuration items that are deemed to be widely available in existing major BGP implementations are included in the model. Additional, more esoteric, configuration items that are not commonly used, or only available from a single implementation, are omitted from the model with an expectation that they will be available in companion modules that augment or extend the current model. This allows clarity in identifying data that is part of the vendor-neutral base model.

Where possible, naming in the model follows conventions used in available standards documents, and otherwise tries to be self-explanatory with sufficient descriptions of the intended behavior. Similarly, configuration data value constraints and default values, where used, are based on recommendations in current standards documentation, or those commonly used in multiple implementations. Since implementations can vary widely in this respect, this version of the model specifies only a limited set of defaults and ranges with the expectation of being more prescriptive in future versions based on actual operator use.

1.2. Note to RFC Editor

This document uses several placeholder values throughout the document. Please replace them as follows and remove this note before publication.

RFC XXXX, where XXXX is the number assigned to this document at the time of publication.

2022-10-13 with the actual date of the publication of this document.

1.3. Terminology

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.

1.4. Abbreviations

Abbreviation	
AFI	Address Family Identifier
BFD	Bidirectional Forward Detection
NLRI	Network Layer Reachability Information
NMDA	Network Management Datastore Architecture
RIB	Routing Information Base
SAFI	Subsequent Address Family Identifier
VRF	Virtual Routing and Forwarding

Table 1

2. Model overview

The BGP model is defined across several YANG modules and submodules, but at a high level is organized into six elements:

- *base protocol configuration -- configuration affecting BGP protocol-related operations, defined at various levels of hierarchy.
- *multi-protocol configuration -- configuration affecting individual address-families within BGP [Multiprotocol Extensions for BGP-4](#) [[RFC4760](#)].
- *neighbor configuration -- configuration affecting an individual neighbor within BGP.
- *neighbor multi-protocol configuration -- configuration affecting individual address-families for a neighbor within BGP.
- *policy configuration -- hooks for application of the policies defined in [A YANG Data Model for Routing Policy Management](#) [[RFC9067](#)] that act on routes sent (received) to (from) peers or other routing protocols and BGP-specific policy features.
- *operational state -- variables used for monitoring and management of BGP operations.

These modules also make use of standard Internet types, such as IP addresses and prefixes, autonomous system numbers, etc., defined in [Common YANG Data Types](#) [[RFC6991](#)].

2.1. BGP protocol configuration

The BGP protocol configuration model is organized hierarchically, much like the majority of router implementations. That is, configuration items can be specified at multiple levels, as shown below.

module: ietf-bgp

augment /rt:routing/rt:control-plane-protocols
/rt:control-plane-protocol:

```
+--rw bgp
  +--rw global!
    | +--rw as inet:as-number
    | +--rw identifier? yang:dotted-quad
    | +--rw distance
    | | ...
    | +--rw confederation
    | | ...
    | +--rw graceful-restart {bt:graceful-restart}?
    | | ...
    | +--rw use-multiple-paths
    | | ...
    | +--rw route-selection-options
    | | ...
    | +--rw afi-safis
    | | ...
    | +--rw apply-policy
    | | ...
    | +--ro statistics
    | ...
  +--rw neighbors
    | +--rw neighbor* [remote-address]
    | | ...
    | +---n established
    | | ...
    | +---n backward-transition
    | | ...
    | +---x clear {bt:clear-neighbors}?
    | ...
  +--rw peer-groups
    | +--rw peer-group* [name]
    | ...
  +--rw interfaces
    | +--rw interface* [name]
    | ...
  +--ro rib
    +--ro attr-sets
    | ...
    +--ro communities
    | ...
    +--ro ext-communities
    | ...
    +--ro large-communities
    | ...
    +--ro afi-safis
```


Users may specify configuration at a higher level and have it apply to all lower-level items, or provide overriding configuration at a lower level of the hierarchy. Overriding configuration items are optional, with neighbor-specific configuration being the most specific or lowest level, followed by peer-group, and finally global. Global configuration options reflect a subset of the peer-group or neighbor-specific configuration options which are relevant to the entire BGP instance.

The model makes the simplifying assumption that most of the configuration items are available at all levels of the hierarchy. That is, very little configuration is specific to a particular level in the hierarchy, other than obvious items such as "group-name" only being available for the peer group-level config. A notable exception is for sub-address family configuration where some items are only applicable for a given AFI-SAFI combination.

In order to allow common configuration to be applied to a set of neighbors, all neighbor configuration options are available within a peer-group. A neighbor is associated with a particular peer-group through the use of a peer-group leaf (which provides a reference to a configured item in the peer-group list).

Address-family configuration is made available in multiple points within the model - primarily within the global container, where instance-wide configuration can be set (for example, global protocol parameters, the BGP best-path route selection options, or global policies relating to the address-family); and on a per-neighbor or per-peer-group basis, where address-families can be enabled or disabled, and policy associated with the parent entity applied. Within the afi-safi container, generic configuration that applies to all address-families (e.g., whether the AFI-SAFI is enabled) is presented at the top-level, with address-family specific containers made available for options relating to only that AFI-SAFI. Within the current revision of the model a generic set of address-families, and common configuration and state options are included - further work is expected to add additional parameters to this area of the model.

The model supports ipv4-unicast and ipv6-unicast address-families and defers the remaining AFI/SAFI to other or future drafts:

```

+--rw bgp
  +--rw global!
    +--rw afi-safis
      +--rw afi-safi* [afi-safi-name]
        +--rw afi-safi-name          identityref
        |
        +--rw ipv4-unicast
        |   ...
        +--rw ipv6-unicast
        |   ...
        +--rw ipv4-labeled-unicast
        |   ...
        +--rw ipv6-labeled-unicast
        |   ...
        +--rw l3vpn-ipv4-unicast
        |   ...
        +--rw l3vpn-ipv6-unicast
        |   ...
        +--rw l3vpn-ipv4-multicast
        |   ...
        +--rw l3vpn-ipv6-multicast
        |   ...
        +--rw l2vpn-vpls
        |   ...
        +--rw l2vpn-evpn
        |   ...

```

2.2. Policy configuration overview

The BGP policy configuration model augments the generic YANG routing policy model described in [A YANG Data Model for Routing Policy Management](#) [RFC9067], which represents a condition-action policy framework for routing. This model adds BGP-specific conditions (e.g., matching on the community attribute), and actions (e.g., setting local preference) to the generic policy framework.

Policies that are defined in the routing-policy model are referenced in multiple places within the model:

- *within the global instance, where a policy applies to all address-families for all peers.
- *on a global AFI-SAFI basis, where policies apply to all peers for a particular address-family.
- *on a per-peer-group or per-neighbor basis - where the policy applies to all address-families for the particular group or neighbor.

*on a per-afi-safi basis within a neighbor or peer-group context,
where the policy is specific to the AFI-SAFI for a a specific
neighbor or group.

```
module: ietf-bgp-policy

augment /rt-pol:routing-policy/rt-pol:defined-sets:
  +--rw bgp-defined-sets
  ...
augment /rt-pol:routing-policy/rt-pol:policy-definitions
  /rt-pol:policy-definition/rt-pol:statements
  /rt-pol:statement/rt-pol:conditions:
  +--rw bgp-conditions
  ...
augment /rt-pol:routing-policy/rt-pol:policy-definitions
  /rt-pol:policy-definition/rt-pol:statements
  /rt-pol:statement/rt-pol:actions:
  +--rw bgp-actions
  ...
```

2.3. BGP RIB overview

The RIB data model represents the BGP RIB contents. The model
supports five logical RIBs per address family.

An abridged version of the tree shows the RIB portion of the tree
diagram.

```
module: ietf-bgp
```

```
augment /rt:routing/rt:control-plane-protocols
  /rt:control-plane-protocol:
    +--rw bgp
      +--ro rib
        +--ro afi-safis
          +--ro afi-safi* [name]
            +--ro name identityref
            +--ro ipv4-unicast
              | +--ro loc-rib
              | | +--ro routes
              | |   +--ro route* [prefix origin path-id]
              | |   ...
              | +--ro neighbors
              |   +--ro neighbor* [neighbor-address]
              |   +--ro neighbor-address inet:ip-address
              |   +--ro adj-rib-in-pre
              |   | ...
              |   +--ro adj-rib-in-post
              |   | ...
              |   +--ro adj-rib-out-pre
              |   | ...
              |   +--ro adj-rib-out-post
              |   ...
            +--ro ipv6-unicast
              +--ro loc-rib
              | +--ro routes
              |   +--ro route* [prefix origin path-id]
              |   ...
            +--ro neighbors
              +--ro neighbor* [neighbor-address]
              +--ro neighbor-address inet:ip-address
              +--ro adj-rib-in-pre
              | ...
              +--ro adj-rib-in-post
              | ...
              +--ro adj-rib-out-pre
              | ...
              +--ro adj-rib-out-post
              ...
```

2.3.1. Local Routing

The loc-rib is the main BGP routing table for the local routing instance, containing best-path selections for each prefix. The loc-rib table may contain multiple routes for a given prefix, with an attribute to indicate which was selected as the best-path. Note that

multiple paths may be used or advertised even if only one path is marked as best, e.g., when using BGP add-paths. An implementation may choose to mark multiple paths in the RIB as best-path by setting the flag to true for multiple entries.

2.3.2. Pre updates per-neighbor

The adj-rib-in-pre table is a per-neighbor table containing the NLRI updates received from the neighbor before any local input policy rules or filters have been applied. This can be considered the 'raw' updates from a given neighbor.

2.3.3. Post updates per-neighbor

The adj-rib-in-post table is a per-neighbor table containing the routes received from the neighbor that are eligible for best-path selection after local input policy rules have been applied.

2.3.4. Pre route advertisements per-neighbor

The adj-rib-out-pre table is a per-neighbor table containing routes eligible for sending (advertising) to the neighbor before output policy rules have been applied.

2.3.5. Post route advertisements per-neighbor

The adj-rib-out-post table is a per-neighbor table containing routes eligible for sending (advertising) to the neighbor after output policy rules have been applied.

3. Relation to other YANG data models

The BGP model augments the Routing Management model [A YANG Data Model for Routing Management \[RFC8349\]](#) which defines the notion of routing, routing protocols, and RIBs. The notion of Virtual Routing and Forwarding (VRF) is derived by using the [YANG Schema Mount \[RFC8528\]](#) to mount the Routing Management module under the [YANG Data Model for Network Instances \[RFC8529\]](#).

Similarly, it augments the [A YANG Data Model for Routing Policy Management \[RFC9067\]](#) to add in BGP-specific conditions and actions to the generic policy model.

4. Security Considerations

The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as [NETCONF \[RFC6241\]](#) or [RESTCONF \[RFC8040\]](#). The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is [Secure Shell \(SSH\) \[RFC6242\]](#). The lowest

RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is [TLS](#) [[RFC8446](#)]. The [NETCONF 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). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. Some of the subtrees and data nodes and their sensitivity/vulnerability are described here.

- The attribute 'as'. If a user is allowed to change this attribute, it will have the net effect of bringing down the entire routing instance, causing it to delete all the current routing entries, and learning new ones.

- The attribute 'identifier'. If a user is allowed to change this attribute, it will have the net effect of this routing instance re-advertising all its routes.

- The attribute 'distance'. If a user is allowed to change this attribute, it will cause the preference for routes, e.g. external vs internal to change.

- The attribute 'enabled' in the 'confederation' container. This attribute defines whether a local-AS is part of a BGP federation.

- Finally, there are a whole set of route selection options such as 'always-compare-med', 'ignore-as-path-length' that affect the way the system picks up a particular route. Being able to change will adversely affect how the route selection happens.

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. Some of the subtrees and data nodes and their sensitivity/vulnerability are:

- The list of neighbors, and their attributes. Allowing a user to read these attributes, in particular the address/port information may allow a malicious user to launch an attack at the particular address/port.

- The 'rib' container. This container contains sensitive information such as attribute sets, communities and external communities. Being able to read the contents of this container will allow a malicious

user to understand how the system decide how to route a packet, and thus try to affect a change.

Some of the RPC operations in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control access to these operations. These are the operations and their sensitivity/vulnerability:

- The model allows for routes to be cleared using the 'clear' RPC operations, causing the entire RIB table to be cleared.
- The model allows for statistics to be cleared by the 'clear' RPC operation, causing all the individual statistics to be cleared.
- The model also allows for neighbors that have been learnt by the system to be cleared by using the 'clear' RPC operation.

[BGP OPSEC](#) [[RFC7454](#)] describes several policies that can be used to secure a BGP. In particular, it recommends securing the underlying TCP session and to use [Generalized TTL Security Mechanism \(GTSM\)](#) [[RFC5082](#)] capability to make it harder to spoof a BGP session. This module allows implementations that want to support the capability to configure a TTL value, under a feature flag. It also defines a container 'secure-session' that contains a choice of using [TCP-Authentication Option \(TCP-AO\)](#) [[RFC5925](#)], or [Protection of BGP Sessions via the TCP MD5 Signature Option](#) [[RFC2385](#)]. The support for MD5 has been made available for legacy reasons. However, because of vulnerabilities in MD5 as described in [MD5 and HMAC-MD5 Security Considerations](#) [[RFC6151](#)], operators are strongly encouraged to use TCP-AO or other methods to secure their BGP session.

5. IANA Considerations

This document registers three URIs and three YANG modules.

5.1. URI Registration

Following the format in the [IETF XML registry](#) [[RFC3688](#)] [[RFC3688](#)], the following registration is requested to be made:

URI: urn:ietf:params:xml:ns:yang:ietf-bgp
URI: urn:ietf:params:xml:ns:yang:ietf-bgp-policy
URI: urn:ietf:params:xml:ns:yang:iana-bgp-types

Registrant Contact: The IESG. XML: N/A, the requested URI is an XML namespace.

5.2. YANG Module Name Registration

This document registers three YANG modules in the YANG Module Names registry [YANG](#) [[RFC6020](#)].

name: ietf-bgp
namespace: urn:ietf:params:xml:ns:yang:ietf-bgp
prefix: bgp
reference: RFC XXXX

name: ietf-bgp-policy
namespace: urn:ietf:params:xml:ns:yang:ietf-bgp-policy
prefix: bp
reference: RFC XXXX

name: iana-bgp-types
namespace: urn:ietf:params:xml:ns:yang:iana-bgp-types
prefix: bt
reference: RFC XXXX

6. YANG modules

The modules comprising the BGP configuration and operational model are described by the YANG modules and submodules in the sections below.

The main module, `ietf-bgp.yang`, includes the following submodules:

- *`ietf-bgp-common` - defines the groupings that are common across more than one context (where contexts are neighbor, group, global)
- *`ietf-bgp-common-multiprotocol` - defines the groupings that are common across more than one context, and relate to multi-protocol BGP
- *`ietf-bgp-common-structure` - defines groupings that are shared by multiple contexts, but are used only to create structural elements, i.e., containers (leaf nodes are defined in separate groupings)
- *`ietf-bgp-neighbor` - groupings with data specific to the neighbor context
- *`ietf-bgp-rib` - grouping for representing BGP RIB.
- *`ietf-bgp-rib-attributes` - common data definitions for BGP attributes used in BGP RIB tables.

*ietf-bgp-rib-tables - structural data definitions for BGP routing tables.

Additionally, modules include:

*iana-bgp-types - common type and identity definitions for BGP, including BGP policy

*ietf-bgp-policy - BGP-specific policy data definitions for use with [\[RFC9067\]](#) (described in more detail [Section 2.2](#))

7. Structure of the YANG modules

The YANG model can be subdivided between the main module for base items, types, and policy module. It references [BGP Communities Attribute \[RFC1997\]](#), [Route Refresh Capability for BGP-4 \[RFC2918\]](#), [NOPEER Community for BGP \[RFC3765\]](#), [BGP Extended Communities Attributes \[RFC4360\]](#), [BGP/MPLS IP Virtual Private Networks \(VPNs\) \[RFC4364\]](#), [BGP MED Considerations \[RFC4451\]](#), [BGP-MPLS IP Virtual Private Network \(VPN\) Extension for IPv6 VPN \[RFC4659\]](#), [Graceful Restart Mechanism for BGP \[RFC4724\]](#), [Multiprotocol Extensions for BGP-4 \[RFC4760\]](#), [Virtual Private LAN Service \(VPLS\) Using BGP for Auto-Discovery and Signaling \[RFC4761\]](#), [Autonomous System Configuration for BGP \[RFC5065\]](#), [The Generalized TTL Security Mechanism \(GTSM\) \[RFC5082\]](#), [Bidirectional Forward Detection \(BFD\) \[RFC5880\]](#), [Bidirectional Forward Detection for IPv4 and IPv6 \(Single Hop\) \[RFC5881\]](#), [Bidirectional Forwarding Detection \(BFD\) for Multihop Paths \[RFC5883\]](#), [The TCP Authentication Option \[RFC5925\]](#), [BGP Encodings and Procedures for Multicast in MPLS/BGP IP VPNs \[RFC6514\]](#), [BGP Support for Four-Octet Autonomous System \(AS\) Number Space \[RFC6793\]](#), [Advertisement of Multiple Paths in BGP \[RFC7911\]](#), [BGP Large Communities Attributes \[RFC8092\]](#), [YANG Key Chain \[RFC8177\]](#), [Carrying Label Information in BGP-4 \[RFC8277\]](#), [A YANG Data Model for Routing Policy \[RFC9067\]](#), [YANG Data Model for Bidirectional Forward Detection \[RFC9127\]](#), [Transmission Control Protocol \[RFC9293\]](#), and [YANG Model for Transmission Control Protocol \(TCP\) Configuration \[I-D.ietf-tcpm-yang-tcp\]](#).

7.1. Modules and submodules for base items

7.1.1.1. ietf-bgp module

<CODE BEGINS> file "ietf-bgp@2022-10-13.yang"

```
module ietf-bgp {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-bgp";
  prefix bgp;

  /*
   * Import and Include
   */

  import ietf-routing {
    prefix rt;
    reference
      "RFC 8349, A YANG Data Model for Routing Management
      (NMDA Version).";
  }
  import ietf-routing-policy {
    prefix rt-pol;
    reference
      "RFC ZZZZ, A YANG Data Model for Routing Policy Management.";
  }
  import ietf-interfaces {
    prefix if;
    reference
      "RFC 8343, A YANG Data Model for Interface Management.";
  }
  import iana-bgp-types {
    prefix bt;
    reference
      "RFC XXXX, BGP YANG Model for Service Provider Network.";
  }
  import ietf-bfd-types {
    prefix bfd-types;
    reference
      "I-D.ietf-bfd-rfc9127-bis: YANG Data Model for
      Bidirectional Forward Detection (BFD).";
  }
  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991: Common YANG Data Types.";
  }
  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 6991: Common YANG Data Types.";
  }
  import ietf-key-chain {
```

```

    prefix key-chain;
    reference
        "RFC 8177: YANG Key Chain.";
}
include ietf-bgp-common {
    revision-date 2022-10-13;
}
include ietf-bgp-common-multiprotocol {
    revision-date 2022-10-13;
}
include ietf-bgp-common-structure {
    revision-date 2022-10-13;
}
include ietf-bgp-neighbor {
    revision-date 2022-10-13;
}
include ietf-bgp-rib-types {
    revision-date 2022-10-13;
}
include ietf-bgp-rib {
    revision-date 2022-10-13;
}
include ietf-bgp-rib-attributes {
    revision-date 2022-10-13;
}
include ietf-bgp-rib-tables {
    revision-date 2022-10-13;
}

organization
    "IETF IDR Working Group";
contact
    "WG Web:  <http://tools.ietf.org/wg/idr>
    WG List:  <idr@ietf.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
            Keyur Patel (keyur at arrcus.com),
            Susan Hares (shares at ndzh.com),
            Jeffrey Haas (jhaas at juniper.net).";

description
    "This module describes a YANG model for BGP protocol
    configuration. It is a limited subset of all of the
    configuration parameters available in the variety of vendor
    implementations, hence it is expected that it would be augmented
    with vendor-specific configuration data as needed. Additional
    modules or submodules to handle other aspects of BGP
    configuration, including policy, VRFs, VPNs, and additional
    address families are also expected."

```

This model supports the following BGP configuration level hierarchy:

```
BGP
|
+--> [ global BGP configuration ]
    +--> AFI / SAFI global
    +--> peer group
        +--> [ peer group config ]
        +--> AFI / SAFI [ per-AFI overrides ]
    +--> neighbor
        +--> [ neighbor config ]
        +--> [ optional pointer to peer-group ]
        +--> AFI / SAFI [ per-AFI overrides ]
```

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This version of this YANG module is part of RFC XXXX (<https://www.rfc-editor.org/info/rfcXXXX>); see the RFC itself for full legal notices.

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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
    "Initial Version";
  reference
    "RFC XXXX, BGP Model for Service Provider Network ";
}
```

```
/*
 * Identity
 */
```

```
identity bgp {
  base rt:routing-protocol;
  description
```

```

    "BGP protocol.";
}

/*
 * Groupings
 */
grouping neighbor-and-peer-group-common {
    description
        "Neighbor and Peer Group configuration that is common.";

    container timers {
        description
            "Timers related to a BGP neighbor";
        uses neighbor-group-timers-config;
    }

    container transport {
        description
            "Transport session parameters for the BGP neighbor";
        uses neighbor-group-transport-config;
    }

    container graceful-restart {
        if-feature "bt:graceful-restart";
        description
            "Parameters relating the graceful restart mechanism for
            BGP";
        uses graceful-restart-config;
        leaf peer-restart-time {
            type uint16 {
                range "0..4096";
            }
            config false;
            description
                "The period of time (advertised by the peer) that the
                peer expects a restart of a BGP session to take.";
        }

        leaf peer-restarting {
            type boolean;
            config false;
            description
                "This flag indicates whether the remote neighbor is
                currently in the process of restarting, and hence
                received routes are currently stale.";
        }

        leaf local-restarting {
            type boolean;

```

```

    config false;
    description
        "This flag indicates whether the local neighbor is
        currently restarting. The flag is cleared after all
        NLRI have been advertised to the peer, and the
        End-of-RIB (EOR) marker has been cleared.";
}

leaf mode {
    type enumeration {
        enum helper-only {
            description
                "The local router is operating in helper-only
                mode, and hence will not retain forwarding state
                during a local session restart, but will do so
                during a restart of the remote peer";
        }
        enum bilateral {
            description
                "The local router is operating in both helper
                mode, and hence retains forwarding state during
                a remote restart, and also maintains forwarding
                state during local session restart";
        }
        enum remote-helper {
            description
                "The local system is able to retain routes during
                restart but the remote system is only able to
                act as a helper";
        }
    }
}
config false;
description
    "This leaf indicates the mode of operation of BGP
    graceful restart with the peer";
}
}

uses structure-neighbor-group-logging-options;
uses structure-neighbor-group-ebgp-multihop;
uses structure-neighbor-group-route-reflector;
uses structure-neighbor-group-as-path-options;
uses structure-neighbor-group-add-paths;
uses bgp-neighbor-use-multiple-paths;
uses rt-pol:apply-policy-group;
}

/*
 * Containers
 */

```



```

augment "/rt:routing/rt:control-plane-protocols/"
  + "rt:control-plane-protocol" {
    when "derived-from-or-self(rt:type, 'bgp')" {
      description
        "This augmentation is valid for a routing protocol
        instance of BGP.";
    }
    description
      "BGP protocol augmentation of ietf-routing module
      control-plane-protocol.";
    container bgp {
      description
        "Top-level configuration for the BGP router.";
      container global {
        presence "Enables global configuration of BGP";
        description
          "Global configuration for the BGP router.";
        leaf as {
          type inet:as-number;
          mandatory true;
          description
            "Local autonomous system number of the router. Uses
            the 32-bit as-number type from the model in RFC 6991.";
        }
        leaf identifier {
          type yang:dotted-quad;
          description
            "BGP Identifier of the router - an unsigned 32-bit,
            non-zero integer that should be unique within an AS.
            The value of the BGP Identifier for a BGP speaker is
            determined upon startup and is the same for every local
            interface and BGP peer.";
          reference
            "RFC 6286: AS-Wide Unique BGP ID for BGP-4. Section 2.1";
        }
      }
      container distance {
        description
          "Administrative distances (or preferences) assigned to
          routes received from different sources (external, and
          internal).";
        leaf external {
          type uint8 {
            range "1..255";
          }
          description
            "Administrative distances for routes learned from
            external BGP (eBGP).";
        }
      }
    }
  }

```

```

leaf internal {
    type uint8 {
        range "1..255";
    }
    description
        "Administrative distances for routes learned from
        internal BGP (iBGP).";
}
}
container confederation {
    description
        "Configuration options specifying parameters when the
        local router is within an autonomous system which is
        part of a BGP confederation.";
    leaf enabled {
        type boolean;
        description
            "When this leaf is set to true it indicates that
            the local-AS is part of a BGP confederation.";
    }
    leaf identifier {
        type inet:as-number;
        description
            "Confederation identifier for the autonomous system.";
    }
    leaf-list member-as {
        type inet:as-number;
        description
            "Remote autonomous systems that are to be treated
            as part of the local confederation.";
    }
}
container graceful-restart {
    if-feature "bt:graceful-restart";
    description
        "Parameters relating the graceful restart mechanism for
        BGP.";
    uses graceful-restart-config;
}
uses global-group-use-multiple-paths;
uses route-selection-options;
container afi-safis {
    description
        "List of address-families associated with the BGP
        instance.";
    list afi-safi {
        key "name";
        description
            "AFI,SAFI configuration available for the

```

```

        neighbor or group.";
    uses mp-afi-safi-config;
    uses state;
    container graceful-restart {
        if-feature "bt:graceful-restart";
        description
            "Parameters relating to BGP graceful-restart";
        uses mp-afi-safi-graceful-restart-config;
    }
    uses route-selection-options;
    uses global-group-use-multiple-paths;
    uses mp-all-afi-safi-list-contents;
}
}
uses rt-pol:apply-policy-group;
uses state;
}

container neighbors {
    description
        "Configuration for BGP neighbors.";

    list neighbor {
        key "remote-address";
        description
            "List of BGP neighbors configured on the local system,
            uniquely identified by remote IPv[46] address.";

        leaf remote-address {
            type inet:ip-address;
            description
                "The remote IP address of this entry's BGP peer.";
        }

        leaf local-address {
            type inet:ip-address;
            config false;
            description
                "The local IP address of this entry's BGP connection.";
        }

        leaf local-port {
            type inet:port-number;
            config false;
            description
                "The local port for the TCP connection between
                the BGP peers.";
        }
    }
}

```

```

leaf remote-port {
    type inet:port-number;
    config false;
    description
        "The remote port for the TCP connection
        between the BGP peers. Note that the
        objects local-addr, local-port, remote-addr, and
        reemote-port provide the appropriate
        reference to the standard MIB TCP
        connection table.";
}

leaf peer-type {
    type bt:peer-type;
    config false;
    description
        "The type of peering session associated with this
        neighbor.";
    reference
        "RFC 4271: A Border Gateway Protocol 4 (BGP-4)
        Section 1.1 for iBGP and eBGP.
        RFC 5065: Autonomous System Configuration
        for Confederation internal and external.";
}

leaf peer-group {
    type leafref {
        path "../..../peer-groups/peer-group/name";
    }
    description
        "The peer-group with which this neighbor is
        associated.";
}

leaf identifier {
    type yang:dotted-quad;
    config false;
    description
        "The BGP Identifier of this entry's BGP peer.
        This entry MUST be 0.0.0.0 unless the
        session state is in the openconfirm or the
        established state.";
    reference
        "RFC 4271, Section 4.2, 'BGP Identifier'.";
}

leaf enabled {
    type boolean;
    default "true";
}

```

```

description
    "Whether the BGP peer is enabled. In cases where the
    enabled leaf is set to false, the local system should
    not initiate connections to the neighbor, and should
    not respond to TCP connections attempts from the
    neighbor. If the state of the BGP session is
    ESTABLISHED at the time that this leaf is set to
    false, the BGP session should be ceased.

    A transition from 'false' to 'true' will cause
    the BGP Manual Start Event to be generated.
    A transition from 'true' to 'false' will cause
    the BGP Manual Stop Event to be generated.
    This parameter can be used to restart BGP peer
    connections. Care should be used in providing
    write access to this object without adequate
    authentication.";
reference
    "RFC 4271, Section 8.1.2.";
}

leaf secure-session-enable {
    type boolean;
    default "false";
    description
        "Does this session need to be secured?";
}

container secure-session {
    when "../secure-session-enable = 'true'";
    description
        "Container for describing how a particular BGP session
        is to be secured.";

    choice option {
        case ao {
            leaf ao-keychain {
                type key-chain:key-chain-ref;
                description
                    "Reference to the key chain that will be used by
                    this model. Applicable for TCP-AO and TCP-MD5
                    only";
                reference
                    "RFC 8177: YANG Key Chain.";
            }
        }
        description
            "Uses TCP-AO to secure the session. Parameters for
            those are defined as a grouping in the TCP YANG
            model.";
    }
}

```

```

        reference
            "RFC 5925 - The TCP Authentication Option.";
    }

    case md5 {
        leaf md5-keychain {
            type key-chain:key-chain-ref;
            description
                "Reference to the key chain that will be used by
                this model. Applicable for TCP-AO and TCP-MD5
                only";
            reference
                "RFC 8177: YANG Key Chain.";
        }
        description
            "Uses TCP-MD5 to secure the session. Parameters for
            those are defined as a grouping in the TCP YANG
            model.";
        reference
            "RFC 5925: The TCP Authentication Option.";
    }

    description
        "Choice of authentication options.";
}

leaf ttl-security {
    if-feature "bt:ttl-security";
    type uint8;
    default "255";
    description
        "BGP Time To Live (TTL) security check.";
    reference
        "RFC 5082: The Generalized TTL Security Mechanism
        (GTSM),
        RFC 7454: BGP Operations and Security.";
}

uses neighbor-group-config;
uses neighbor-and-peer-group-common;

container afi-safis {
    description
        "Per-address-family configuration parameters associated
        with the neighbor";
    uses bgp-neighbor-afi-safi-list;
}

leaf session-state {

```

```

type enumeration {
    enum idle {
        description
            "Neighbor is down, and in the Idle state of the
            FSM.";
    }
    enum connect {
        description
            "Neighbor is down, and the session is waiting for
            the underlying transport session to be
            established.";
    }
    enum active {
        description
            "Neighbor is down, and the local system is awaiting
            a connection from the remote peer.";
    }
    enum opensent {
        description
            "Neighbor is in the process of being established.
            The local system has sent an OPEN message.";
    }
    enum openconfirm {
        description
            "Neighbor is in the process of being established.
            The local system is awaiting a NOTIFICATION or
            KEEPALIVE message.";
    }
    enum established {
        description
            "Neighbor is up - the BGP session with the peer is
            established.";
    }
}
// notification does not like a non-config statement.
// config false;
description
    "The BGP peer connection state.";
reference
    "RFC 4271, Section 8.1.2.";
}
leaf last-established {
    type yang:date-and-time;
    config false;
    description
        "This timestamp indicates the time that the BGP session
        last transitioned in or out of the Established state.
        The value is the timestamp in seconds relative to the
        Unix Epoch (Jan 1, 1970 00:00:00 UTC).

```

```

        The BGP session uptime can be computed by clients as
        the difference between this value and the current time
        in UTC (assuming the session is in the ESTABLISHED
        state, per the session-state leaf).";
    }
    leaf-list negotiated-capabilities {
        type identityref {
            base bt:bgp-capability;
        }
        config false;
        description
            "Negotiated BGP capabilities.";
    }
    leaf negotiated-hold-time {
        type uint16;
        config false;
        description
            "The negotiated hold-time for the BGP session";
    }
    leaf last-error {
        type binary {
            length "2";
        }
        config false;
        description
            "The last error code and subcode seen by this
            peer on this connection.  If no error has
            occurred, this field is zero.  Otherwise, the
            first byte of this two byte OCTET STRING
            contains the error code, and the second byte
            contains the subcode.";
        reference
            "RFC 4271, Section 4.5.";
    }
    leaf fsm-established-time {
        type yang:gauge32;
        units "seconds";
        config false;
        description
            "This timer indicates how long (in
            seconds) this peer has been in the
            established state or how long
            since this peer was last in the
            established state.  It is set to zero when
            a new peer is configured or when the router is
            booted.";
        reference
            "RFC 4271, Section 8.";
    }

```



```

}
leaf treat-as-withdraw {
    type boolean;
    default "false";
    description
        "Specify whether erroneous UPDATE messages for which
        the NLRI can be extracted are treated as though the
        NLRI is withdrawn - avoiding session reset";
    reference
        "RFC 7606: Revised Error Handling for BGP UPDATE
        Messages.";
}
leaf erroneous-update-messages {
    type uint32;
    config false;
    description
        "The number of BGP UPDATE messages for which the
        treat-as-withdraw mechanism has been applied based on
        erroneous message contents";
}

container bfd {
    if-feature "bt:bfd";
    uses bfd-types:client-cfg-parms;
    description
        "BFD configuration per-neighbor.";
}

container statistics {
    config false;
    description
        "Statistics per neighbor.";

    leaf peer-fsm-established-transitions {
        type yang:zero-based-counter64;
        description
            "Number of transitions to the Established state for
            the neighbor session. This value is analogous to the
            bgpPeerFsmEstablishedTransitions object from the
            standard BGP-4 MIB";
        reference
            "RFC 4273, Definitions of Managed Objects for
            BGP-4.";
    }
    leaf fsm-established-transitions {
        type yang:zero-based-counter32;
        description
            "The total number of times the BGP FSM
            transitioned into the established state

```

```

        for this peer.";
    reference
        "RFC 4271, Section 8.";
}
container messages {
    description
        "Counters for BGP messages sent and received from the
        neighbor";
    leaf in-total-messages {
        type yang:zero-based-counter32;
        description
            "The total number of messages received
            from the remote peer on this connection.";
        reference
            "RFC 4271, Section 4.";
    }
    leaf out-total-messages {
        type yang:zero-based-counter32;
        description
            "The total number of messages transmitted to
            the remote peer on this connection.";
        reference
            "RFC 4271, Section 4.";
    }
    leaf in-update-elapsed-time {
        type yang:gauge32;
        units "seconds";
        description
            "Elapsed time (in seconds) since the last BGP
            UPDATE message was received from the peer.
            Each time in-updates is incremented,
            the value of this object is set to zero (0).";
        reference
            "RFC 4271, Section 4.3.
            RFC 4271, Section 8.2.2, Established state.";
    }
}
container sent {
    description
        "Counters relating to BGP messages sent to the
        neighbor";
    uses bgp-neighbor-counters-message-types-state;
}
container received {
    description
        "Counters for BGP messages received from the
        neighbor";
    uses bgp-neighbor-counters-message-types-state;
}
}

```

```

container queues {
  description
    "Counters related to queued messages associated with
    the BGP neighbor";
  leaf input {
    type yang:counter32;
    description
      "The number of messages received from the peer
      currently queued";
  }
  leaf output {
    type yang:counter32;
    description
      "The number of messages queued to be sent to the
      peer";
  }
}
action clear {
  if-feature "bt:clear-statistics";
  description
    "Clear statistics action command.

    Execution of this command should result in all the
    counters to be cleared and set to 0.";

  input {
    leaf clear-at {
      type yang:date-and-time;
      description
        "Time when the clear action needs to be
        executed.";
    }
  }
  output {
    leaf clear-finished-at {
      type yang:date-and-time;
      description
        "Time when the clear action command completed.";
    }
  }
}

notification established {
  leaf remote-address {
    type leafref {
      path "../neighbor/remote-address";
    }
  }
}

```

```

        description
            "IP address of the neighbor that went into established
            state.";
    }
    leaf last-error {
        type leafref {
            path "../../neighbor/last-error";
        }
        description
            "The last error code and subcode seen by this
            peer on this connection.  If no error has
            occurred, this field is zero.  Otherwise, the
            first octet of this two byte OCTET STRING
            contains the error code, and the second octet
            contains the subcode.";
        reference
            "RFC 4271, Section 4.5.";
    }
    leaf session-state {
        type leafref {
            path "../../neighbor/session-state";
        }
        description
            "The BGP peer connection state.";
        reference
            "RFC 4271, Section 8.2.2.";
    }
    description
        "The established event is generated
        when the BGP FSM enters the established state.";
}

notification backward-transition {
    leaf remote-addr {
        type leafref {
            path "../../neighbor/remote-address";
        }
        description
            "IP address of the neighbor that changed its state from
            established state.";
    }
    leaf last-error {
        type leafref {
            path "../../neighbor/last-error";
        }
        description
            "The last error code and subcode seen by this
            peer on this connection.  If no error has
            occurred, this field is zero.  Otherwise, the

```

```

        first byte of this two byte OCTET STRING
        contains the error code, and the second byte
        contains the subcode.";
    reference
        "RFC 4271, Section 4.5.";
}
leaf session-state {
    type leafref {
        path "../../neighbor/session-state";
    }
    description
        "The BGP peer connection state.";
    reference
        "RFC 4271, Section 8.2.2.";
}
description
    "The backward-transition event is
    generated when the BGP FSM moves from a higher
    numbered state to a lower numbered state.";
}
action clear {
    if-feature "bt:clear-neighbors";
    description
        "Clear neighbors action.";

    input {
        choice operation {
            default operation-admin;
            description
                "The type of operation for the clear action.";
            case operation-admin {
                leaf admin {
                    type empty;
                    description
                        "Closes the Established BGP session with a BGP
                        NOTIFICATION message with the Administrative
                        Reset error subcode.";
                    reference
                        "RFC 4486 - Subcodes for BGP Cease Notification
                        Message.";
                }
            }
            case operation-hard {
                leaf hard {
                    type empty;
                    description
                        "Closes the Established BGP session with a BGP
                        NOTIFICATION message with the Hard Reset error
                        subcode.";
                }
            }
        }
    }
}

```

```

        reference
            "RFC 8538, Section 3 - Notification Message
            Support for BGP Graceful Restart.";
    }
}
case operation-soft {
    leaf soft {
        type empty;
        description
            "Re-sends the current Adj-Rib-Out to this
            neighbor.";
    }
}
case operation-soft-inbound {
    leaf soft-inbound {
        if-feature "bt:route-refresh";
        type empty;
        description
            "Requests the Adj-Rib-In for this neighbor to be
            re-sent using the BGP Route Refresh feature.";
    }
}
}

leaf clear-at {
    type yang:date-and-time;
    description
        "Time when the clear action command needs to be
        executed.";
}
}
output {
    leaf clear-finished-at {
        type yang:date-and-time;
        description
            "Time when the clear action command completed.";
    }
}
}
}

container peer-groups {
    description
        "Configuration for BGP peer-groups";

    list peer-group {
        key "name";
        description

```

"List of BGP peer-groups configured on the local system -
uniquely identified by peer-group name";

```
leaf name {  
    type string;  
    description  
        "Name of the BGP peer-group";  
}
```

```
leaf secure-session-enable {  
    type boolean;  
    default "false";  
    description  
        "Does this session need to be secured?";  
}
```

```
container secure-session {  
    when "../secure-session-enable = 'true'";  
    description  
        "Container for describing how a particular BGP session  
        is to be secured.";
```

```
    choice option {  
        case ao {  
            leaf ao-keychain {  
                type key-chain:key-chain-ref;  
                description  
                    "Reference to the key chain that will be used by  
                    this model. Applicable for TCP-AO and TCP-MD5  
                    only";  
                reference  
                    "RFC 8177: YANG Key Chain.";  
            }  
            description  
                "Uses TCP-AO to secure the session. Parameters for  
                those are defined as a grouping in the TCP YANG  
                model.";  
            reference  
                "RFC 5925 - The TCP Authentication Option.";  
        }  
        case md5 {  
            leaf md5-keychain {  
                type key-chain:key-chain-ref;  
                description  
                    "Reference to the key chain that will be used by  
                    this model. Applicable for TCP-AO and TCP-MD5  
                    only";  
                reference  
                    "RFC 8177: YANG Key Chain.";
```

```

    }
    description
        "Uses TCP-MD5 to secure the session. Parameters for
        those are defined as a grouping in the TCP YANG
        model.";
    reference
        "RFC 5925: The TCP Authentication Option.";
}
case ipsec {
    leaf sa {
        type string;
        description
            "Security Association (SA) name.";
    }
    description
        "Currently, the IPsec/IKE YANG model has no
        grouping defined that this model can use. When
        such a grouping is defined, this model can import
        the grouping to add the key parameters
        needed to kick off IKE.";
}
description
    "Choice of authentication options.";
}
}

leaf ttl-security {
    if-feature "bt:ttl-security";
    type uint8;
    default "255";
    description
        "BGP Time To Live (TTL) security check.";
    reference
        "RFC 5082: The Generalized TTL Security Mechanism
        (GTSM),
        RFC 7454: BGP Operations and Security.";
}

uses neighbor-group-config;
uses neighbor-and-peer-group-common;

container afi-safis {
    description
        "Per-address-family configuration parameters
        associated with the peer-group.";
    list afi-safi {
        key "name";
        description
            "AFI, SAFI configuration available for the

```



```

        neighbor or group";
    uses mp-afi-safi-config;
    container graceful-restart {
        if-feature "bt:graceful-restart";
        description
            "Parameters relating to BGP graceful-restart";
        uses mp-afi-safi-graceful-restart-config;
    }
    uses bgp-neighbor-use-multiple-paths;
    uses mp-all-afi-safi-list-contents;
}
}
}

container interfaces {
    list interface {
        key "name";
        leaf name {
            type if:interface-ref;
            description
                "Reference to the interface within the routing
                instance.";
        }
    }

    container bfd {
        if-feature "bt:bfd";
        leaf enabled {
            type boolean;
            default "false";
            description
                "Indicates whether BFD is enabled on this
                interface.";
        }
        description
            "BFD client configuration.";
        reference
            "I-D.ietf-bfd-rfc9127-bis: YANG Data Model for
            Bidirectional Forward Detection (BFD).";
    }
    description
        "List of interfaces within the routing instance.";
}
description
    "Interface specific parameters.";
}
uses rib;
}
}

```

}

<CODE ENDS>

7.1.2. ietf-bgp-common submodule

<CODE BEGINS> file "ietf-bgp-common@2022-10-13.yang"

```
submodule ietf-bgp-common {
  yang-version 1.1;
  belongs-to ietf-bgp {
    prefix bgp;
  }

  import iana-bgp-types {
    prefix bt;
    reference
      "RFC XXXX: BGP Model for Service Provider Network.";
  }
  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991: Common YANG Data Types.";
  }
  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 6991: Common YANG Data Types.";
  }
  import ietf-bfd-types {
    prefix bfd-types;
    reference
      "RFC XXXX, YANG Data Model for Bidirectional Forward
      Detection.";
  }
  import ietf-tcp {
    prefix tcp;
    reference
      "I-D.ietf-tcpm-yang-tcp: Transmission Control Protocol (TCP)
      YANG Model.";
  }

  organization
    "IETF IDR Working Group";
  contact
    "WG Web:  <http://tools.ietf.org/wg/idr>
    WG List:  <idr@ietf.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
             Keyur Patel (keyur at arrcus.com),
             Susan Hares (shares at ndzh.com),
             Jeffrey Haas (jhaas at juniper.net).";

  description
    "This sub-module contains common groupings that are common across
```

multiple contexts within the BGP module. That is to say that they may be application to a subset of global, peer-group, or neighbor contexts.

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This version of this YANG module is part of RFC XXXX (<https://www.rfc-editor.org/info/rfcXXXX>); see the RFC itself for full legal notices.

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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
    "Initial Version";
  reference
    "RFC XXXX, BGP Model for Service Provider Network.";
}

grouping neighbor-group-timers-config {
  description
    "Config parameters related to timers associated with the BGP
    peer";
  leaf connect-retry-interval {
    type uint16 {
      range "1..max";
    }
    units "seconds";
    default "120";
    description
      "Time interval (in seconds) for the ConnectRetryTimer. The
      suggested value for this timer is 120 seconds.";
    reference
      "RFC 4271, Section 8.2.2. This is the value used
      to initialize the 'ConnectRetryTimer'.";
  }
  leaf hold-time {
```

```

type uint16 {
    range "0 | 3..65535";
}
units "seconds";
default "90";
description
    "Time interval (in seconds) for the HoldTimer established
    with the peer. When read as operational data (ro), the
    value of this object is calculated by this BGP speaker,
    using the smaller of the values in hold-time that was
    configured (rw) in the running datastore and the Hold Time
    received in the OPEN message.

    This value must be at least three seconds
    if it is not zero (0).

    If the Hold Timer has not been established
    with the peer this object MUST have a value
    of zero (0).

    If the configured value of hold-time object was
    a value of (0), then when read this object MUST have a
    value of (0) also.";
reference
    "RFC 4271, Section 4.2.
    RFC 4271, Section 10.";
}
leaf keepalive {
    type uint16 {
        range "0..21845";
    }
    units "seconds";
    description
        "When used as a configuration (rw) value, this Time interval
        (in seconds) for the KeepAlive timer configured for this BGP
        speaker with this peer. A reasonable maximum value for this
        timer would be one-third of the configured hold-time.

        In the absence of explicit configuration of the keepalive
        value, operationally it SHOULD have a value of one-third of
        the negotiated hold-time.

        If the value of this object is zero (0), no periodic
        KEEPALIVE messages are sent to the peer after the BGP
        connection has been established.

        The actual time interval for the KEEPALIVE messages is
        indicated by operational value of keepalive.";
    reference

```

```

        "RFC 4271, Section 4.4.
        RFC 4271, Section 10.";
    }
    leaf min-as-origination-interval {
        type uint16 {
            range "0..max";
        }
        units "seconds";
        description
            "Time interval (in seconds) for the MinASOriginationInterval
            timer. The suggested value for this timer is 15 seconds.";
        reference
            "RFC 4271, Section 9.2.1.2.
            RFC 4271, Section 10.";
    }
    leaf min-route-advertisement-interval {
        type uint16 {
            range "0..max";
        }
        units "seconds";
        description
            "Time interval (in seconds) for the
            MinRouteAdvertisementInterval timer.
            The suggested value for this timer is 30
            seconds for EBGp connections and 5
            seconds for IBGP connections.";
        reference
            "RFC 4271, Section 9.2.1.1.
            RFC 4271, Section 10.";
    }
}

grouping neighbor-group-config {
    description
        "Neighbor level configuration items.";
    leaf peer-as {
        type inet:as-number;
        description
            "AS number of the peer.";
    }
    leaf local-as {
        type inet:as-number;
        description
            "The local autonomous system number that is to be used when
            establishing sessions with the remote peer or peer group, if
            this differs from the global BGP router autonomous system
            number.";
    }
}

```

```

leaf remove-private-as {
    type bt:remove-private-as-option;
    description
        "When this leaf is specified, remove private AS numbers from
        updates sent to peers.";
}
container route-flap-damping {
    if-feature "bt:damping";
    leaf enable {
        type boolean;
        default "false";
        description
            "Enable route flap damping.";
    }
    leaf suppress-above {
        type decimal64 {
            fraction-digits 1;
        }
        default "3.0";
        description
            "This is the value of the instability metric at which
            route suppression takes place. A route is not installed
            in the forwarding information base (FIB), or announced
            even if it is reachable during the period that it is
            suppressed.";
    }
    leaf reuse-above {
        type decimal64 {
            fraction-digits 1;
        }
        default "2.0";
        description
            "This is the value of the instability metric at which a
            suppressed route becomes unsuppressed if it is reachable
            but currently suppressed. The value assigned to
            reuse-below must be less than suppress-above.";
    }
    leaf max-flap {
        type decimal64 {
            fraction-digits 1;
        }
        default "16.0";
        description
            "This is the upper limit of the instability metric. This
            value must be greater than the larger of 1 and
            suppress-above.";
    }
    leaf reach-decay {
        type uint32;
    }
}

```



```

    units "seconds";
    default "300";
    description
        "This value specifies the time desired for the instability
        metric value to reach one-half of its current value when
        the route is reachable. This half-life value determines
        the rate at which the metric value is decayed. A smaller
        half-life value makes a suppressed route reusable sooner
        than a larger value.";
}
leaf unreach-decay {
    type uint32;
    units "seconds";
    default "900";
    description
        "This value acts the same as reach-decay except that it
        specifies the rate at which the instability metric is
        decayed when a route is unreachable. It should have a
        value greater than or equal to reach-decay.";
}
leaf keep-history {
    type uint32;
    units "seconds";
    default "1800";
    description
        "This value specifies the period over which the route
        flapping history is to be maintained for a given route.
        The size of the configuration arrays described below is
        directly affected by this value.";
}
description
    "Routes learned via BGP are subject to weighted route
    dampening.";
}
leaf-list send-community {
    if-feature "bt:send-communities";
    type identityref {
        base "bt:send-community-feature";
    }
    description
        "When supported, this tells the router to propagate any
        prefixes that are attached to these community-types.";
}
leaf description {
    type string;
    description
        "An optional textual description (intended primarily for use
        with a peer or group";
}

```

```

}

grouping neighbor-group-transport-config {
  description
    "Configuration parameters relating to the transport protocol
    used by the BGP session to the peer.";

  leaf tcp-mss {
    type tcp:mss;
    description
      "Maximum Segment Size (MSS) desired on this connection.
      Note, the 'effective send MSS' can be smaller than
      what is configured here.";
    reference
      "RFC 9293: Transmission Control Protocol (TCP)
      Specification.";
  }

  leaf mtu-discovery {
    type boolean;
    default "true";
    description
      "Turns path mtu discovery for BGP TCP sessions on (true) or
      off (false).";
    reference
      "RFC 1191: Path MTU discovery.";
  }

  leaf passive-mode {
    type boolean;
    default "false";
    description
      "Wait for peers to issue requests to open a BGP session,
      rather than initiating sessions from the local router.";
  }

  leaf local-address {
    type union {
      type inet:ip-address;
      type leafref {
        path "../../../../../interfaces/interface/name";
      }
    }
    description
      "Set the local IP (either IPv4 or IPv6) address to use for
      the session when sending BGP update messages. This may be
      expressed as either an IP address or reference to the name
      of an interface.";
  }
}

```

```

container bfd {
    if-feature "bt:bfd";
    uses bfd-types:client-cfg-parms;
    description
        "BFD client configuration.";
    reference
        "RFC XXXX, YANG Data Model for Bidirectional Forwarding
        Detection.";
}
}

grouping graceful-restart-config {
    description
        "Configuration parameters relating to BGP graceful restart.";
    leaf enabled {
        type boolean;
        default "false";
        description
            "Enable or disable the graceful-restart capability.";
    }
    leaf restart-time {
        type uint16 {
            range "0..4096";
        }
        description
            "Estimated time (in seconds) for the local BGP speaker to
            restart a session. This value is advertise in the graceful
            restart BGP capability. This is a 12-bit value, referred to
            as Restart Time in RFC4724. Per RFC4724, the suggested
            default value is <= the hold-time value.";
        reference
            "RFC 4724: Graceful Restart Mechanism for BGP.";
    }
    leaf stale-routes-time {
        type uint32;
        description
            "An upper-bound on the time that stale routes will be
            retained by a router after a session is restarted. If an
            End-of-RIB (EOR) marker is received prior to this timer
            expiring, stale-routes will be flushed upon its receipt - if
            no EOR is received, then when this timer expires stale paths
            will be purged. This timer is referred to as the
            Selection_Deferral_Timer in RFC4724";
        reference
            "RFC 4724: Graceful Restart Mechanism for BGP.";
    }
    leaf helper-only {
        type boolean;
    }
}

```

```

    default "true";
    description
        "Enable graceful-restart in helper mode only. When this leaf
        is set, the local system does not retain forwarding its own
        state during a restart, but supports procedures for the
        receiving speaker, as defined in RFC4724.";
    reference
        "RFC 4724: Graceful Restart Mechanism for BGP.";
}
}

grouping global-group-use-multiple-paths {
    description
        "Common grouping used for both global and groups which provides
        configuration and state parameters relating to use of multiple
        paths";
    container use-multiple-paths {
        description
            "Parameters related to the use of multiple paths for the
            same NLRI";
        leaf enabled {
            type boolean;
            default "false";
            description
                "Whether the use of multiple paths for the same NLRI is
                enabled for the neighbor. This value is overridden by any
                more specific configuration value.";
        }
        container ebgp {
            description
                "Multi-Path parameters for eBGP";
            leaf allow-multiple-as {
                type boolean;
                default "false";
                description
                    "Allow multi-path to use paths from different neighboring
                    ASes. The default is to only consider multiple paths
                    from the same neighboring AS.";
            }
            leaf maximum-paths {
                type uint32;
                default "1";
                description
                    "Maximum number of parallel paths to consider when using
                    BGP multi-path. The default is use a single path.";
            }
        }
    }
}
container ibgp {
    description

```

```

    "Multi-Path parameters for iBGP";
  leaf maximum-paths {
    type uint32;
    default "1";
    description
      "Maximum number of parallel paths to consider when using
        iBGP multi-path. The default is to use a single path";
  }
}
}
}

grouping route-selection-options {
  description
    "Configuration and state relating to route selection options";
  container route-selection-options {
    description
      "Parameters relating to options for route selection";
    leaf always-compare-med {
      type boolean;
      default "false";
      description
        "Compare multi-exit discriminator (MED) value from
          different ASes when selecting the best route. The default
          behavior is to only compare MEDs for paths received from
          the same AS.";
    }
    leaf ignore-as-path-length {
      type boolean;
      default "false";
      description
        "Ignore the AS path length when selecting the best path.
          The default is to use the AS path length and prefer paths
          with a shorter length.";
    }
    leaf external-compare-router-id {
      type boolean;
      default "true";
      description
        "When comparing similar routes received from external BGP
          peers, use the router-id as a criterion to select the
          active path.";
    }
    leaf advertise-inactive-routes {
      type boolean;
      default "false";
      description
        "Advertise inactive routes to external peers. The default
          is to only advertise active routes.";
    }
  }
}

```

```

        reference
            "I-D.ietf-idr-best-external: Advertisement of the best
            external route in BGP.";
    }
    leaf enable-aigp {
        type boolean;
        default "false";
        description
            "Flag to enable sending / receiving accumulated IGP
            attribute in routing updates";
        reference
            "RFC 7311: AIGP Metric Attribute for BGP.";
    }
    leaf ignore-next-hop-igp-metric {
        type boolean;
        default "false";
        description
            "Ignore the IGP metric to the next-hop when calculating BGP
            best-path. The default is to select the route for which
            the metric to the next-hop is lowest";
    }
    leaf enable-med {
        type boolean;
        default "false";
        description
            "Flag to enable sending/receiving of MED metric attribute
            in routing updates.";
    }
    container med-plus-igp {
        leaf enabled {
            type boolean;
            default "false";
            description
                "When enabled allows BGP to use MED and IGP values
                defined below to determine the optimal route.";
            reference
                "RFC 4451: BGP MED Considerations.";
        }
        leaf igp-multiplier {
            type uint16;
            default 1;
            description
                "Specifies an IGP cost multiplier.";
            reference
                "RFC 4451: BGP MED Considerations.";
        }
        leaf med-multiplier {
            type uint16;
            default 1;

```

```

        description
            "Specifies a MED multiplier.";
        reference
            "RFC 4451: BGP MED Considerations.";
    }
    description
        "The med-plus-igp option enables BGP to use the sum of
        MED multiplied by a MED multiplier and IGP cost multiplied
        by IGP cost multiplier to select routes when MED is
        required to determine the optimal route.";
    }
}

grouping state {
    description
        "Grouping containing common counters relating to prefixes and
        paths";

    container statistics {
        config false;
        description
            "Global level statistics.";

        leaf total-paths {
            type yang:gauge32;
            description
                "Total number of BGP paths (BGP routes) within the
                context";
        }

        leaf total-prefixes {
            type yang:gauge32;
            description
                "Total number of BGP prefixes (destinations) received
                within the context";
        }
    }
}
}

```

<CODE ENDS>

7.1.3. ietf-bgp-common-multiprotocol submodule

<CODE BEGINS> file "ietf-bgp-common-multiprotocol@2022-10-13.yang"

```
submodule ietf-bgp-common-multiprotocol {
  yang-version 1.1;
  belongs-to ietf-bgp {
    prefix bgp;
  }

  import iana-bgp-types {
    prefix bt;
  }
  import ietf-routing-policy {
    prefix rt-pol;
  }
  import ietf-routing-types {
    prefix rt-types;
  }
  include ietf-bgp-common;

  // meta

  organization
    "IETF IDR Working Group";
  contact
    "WG Web:  <http://tools.ietf.org/wg/idr>
    WG List:  <idr@ietf.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
             Keyur Patel (keyur at arccus.com),
             Susan Hares (shares at ndzh.com),
             Jeffrey Haas (jhaas at juniper.net).";

  description
    "This sub-module contains groupings that are related to support
    for multiple protocols in BGP. The groupings are common across
    multiple contexts.

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    authors of the code. All rights reserved.

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    Relating to IETF Documents
    (https://trustee.ietf.org/license-info).

    This version of this YANG module is part of RFC XXXX
    (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
    for full legal notices.
```

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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
    "Initial Version";
  reference
    "RFC XXX, BGP Model for Service Provider Network.";
}

grouping mp-afi-safi-graceful-restart-config {
  description
    "BGP graceful restart parameters that apply on a per-AFI-SAFI
    basis";
  leaf enabled {
    type boolean;
    must ". = ../../../../graceful-restart/enabled";
    default "false";
    description
      "This leaf indicates whether graceful-restart is enabled for
      this AFI-SAFI.";
  }
}

grouping mp-afi-safi-config {
  description
    "Configuration parameters used for all BGP AFI-SAFIs";
  leaf name {
    type identityref {
      base bt:afi-safi-type;
    }
    description
      "AFI,SAFI";
  }
  leaf enabled {
    type boolean;
    default "false";
    description
      "This leaf indicates whether this AFI,SAFI is enabled for
      the neighbor or group";
  }
}

grouping mp-all-afi-safi-list-contents {
  description
```

```

    "A common grouping used for contents of the list that is used
    for AFI-SAFI entries";
// import and export policy included for the afi/safi
uses rt-pol:apply-policy-group;
container ipv4-unicast {
    when "../name = 'bt:ipv4-unicast'" {
        description
            "Include this container for IPv4 Unicast specific
            configuration";
    }
    description
        "IPv4 unicast configuration options";
    // include common IPv[46] unicast options
    uses mp-ipv4-ipv6-unicast-common;
    // placeholder for IPv4 unicast specific configuration
}
container ipv6-unicast {
    when "../name = 'bt:ipv6-unicast'" {
        description
            "Include this container for IPv6 Unicast specific
            configuration";
    }
    description
        "IPv6 unicast configuration options";
    // include common IPv[46] unicast options
    uses mp-ipv4-ipv6-unicast-common;
    // placeholder for IPv6 unicast specific configuration
    // options
}
container ipv4-labeled-unicast {
    when "../name = 'bt:ipv4-labeled-unicast'" {
        description
            "Include this container for IPv4 Labeled Unicast specific
            configuration";
    }
    description
        "IPv4 Labeled Unicast configuration options";
    uses mp-all-afi-safi-common;
    // placeholder for IPv4 Labeled Unicast specific config
    // options
}
container ipv6-labeled-unicast {
    when "../name = 'bt:ipv6-labeled-unicast'" {
        description
            "Include this container for IPv6 Labeled Unicast specific
            configuration";
    }
    description
        "IPv6 Labeled Unicast configuration options";
}

```

```

    uses mp-all-afi-safi-common;
    // placeholder for IPv6 Labeled Unicast specific config
    // options.
}
container l3vpn-ipv4-unicast {
    when "../name = 'bt:l3vpn-ipv4-unicast'" {
        description
            "Include this container for IPv4 Unicast L3VPN specific
            configuration";
    }
    description
        "Unicast IPv4 L3VPN configuration options";
    // include common L3VPN configuration options
    uses mp-l3vpn-ipv4-ipv6-unicast-common;
    // placeholder for IPv4 Unicast L3VPN specific config options.
}
container l3vpn-ipv6-unicast {
    when "../name = 'bt:l3vpn-ipv6-unicast'" {
        description
            "Include this container for unicast IPv6 L3VPN specific
            configuration";
    }
    description
        "Unicast IPv6 L3VPN configuration options";
    // include common L3VPN configuration options
    uses mp-l3vpn-ipv4-ipv6-unicast-common;
    // placeholder for IPv6 Unicast L3VPN specific configuration
    // options
}
container l3vpn-ipv4-multicast {
    when "../name = 'bt:l3vpn-ipv4-multicast'" {
        description
            "Include this container for multicast IPv6 L3VPN specific
            configuration";
    }
    description
        "Multicast IPv4 L3VPN configuration options";
    // include common L3VPN multicast options
    uses mp-l3vpn-ipv4-ipv6-multicast-common;
    // placeholder for IPv4 Multicast L3VPN specific configuration
    // options
}
container l3vpn-ipv6-multicast {
    when "../name = 'bt:l3vpn-ipv6-multicast'" {
        description
            "Include this container for multicast IPv6 L3VPN specific
            configuration";
    }
    description

```

```

        "Multicast IPv6 L3VPN configuration options";
    // include common L3VPN multicast options
    uses mp-l3vpn-ipv4-ipv6-multicast-common;
    // placeholder for IPv6 Multicast L3VPN specific configuration
    // options
}
container l2vpn-vpls {
    when "../name = 'bt:l2vpn-vpls'" {
        description
            "Include this container for BGP-signalled VPLS specific
            configuration";
    }
    description
        "BGP-signalled VPLS configuration options";
    // include common L2VPN options
    uses mp-l2vpn-common;
    // placeholder for BGP-signalled VPLS specific configuration
    // options
}
container l2vpn-evpn {
    when "../name = 'bt:l2vpn-evpn'" {
        description
            "Include this container for BGP EVPN specific
            configuration";
    }
    description
        "BGP EVPN configuration options";
    // include common L2VPN options
    uses mp-l2vpn-common;
    // placeholder for BGP EVPN specific configuration options
}
}

// Common groupings across multiple AFI,SAFIs

grouping mp-all-afi-safi-common {
    description
        "Grouping for configuration common to all AFI,SAFI";
    container prefix-limit {
        description
            "Parameters relating to the prefix limit for the AFI-SAFI";
        leaf max-prefixes {
            type uint32;
            description
                "Maximum number of prefixes that will be accepted from the
                neighbor";
        }
        leaf shutdown-threshold-pct {
            type rt-types:percentage;

```

```

        description
            "Threshold on number of prefixes that can be received from
            a neighbor before generation of warning messages or log
            entries. Expressed as a percentage of max-prefixes";
    }
    leaf restart-timer {
        type uint32;
        units "seconds";
        description
            "Time interval in seconds after which the BGP session is
            re-established after being torn down due to exceeding the
            max-prefix limit.";
    }
}

grouping mp-ipv4-ipv6-unicast-common {
    description
        "Common configuration that is applicable for IPv4 and IPv6
        unicast";
    // include common afi-safi options.
    uses mp-all-afi-safi-common;
    // configuration options that are specific to IPv[46] unicast
    leaf send-default-route {
        type boolean;
        default "false";
        description
            "If set to true, send the default-route to the neighbor(s)";
    }
}

grouping mp-l3vpn-ipv4-ipv6-unicast-common {
    description
        "Common configuration applied across L3VPN for IPv4
        and IPv6";
    // placeholder -- specific configuration options that are generic
    // across IPv[46] unicast address families.
    uses mp-all-afi-safi-common;
}

grouping mp-l3vpn-ipv4-ipv6-multicast-common {
    description
        "Common configuration applied across L3VPN for IPv4
        and IPv6";
    // placeholder -- specific configuration options that are
    // generic across IPv[46] multicast address families.
    uses mp-all-afi-safi-common;
}

```

```
grouping mp-l2vpn-common {
    description
        "Common configuration applied across L2VPN address
        families";
    // placeholder -- specific configuration options that are
    // generic across L2VPN address families
    uses mp-all-afi-safi-common;
}

// Config groupings for common groups

grouping mp-all-afi-safi-common-prefix-limit-config {
    description
        "Configuration parameters relating to prefix-limits for an
        AFI-SAFI";
}
}

<CODE ENDS>
```

7.1.4. ietf-bgp-common-structure submodule


```

<CODE BEGINS> file "ietf-bgp-common-structure@2022-10-13.yang"

submodule ietf-bgp-common-structure {
  yang-version 1.1;
  belongs-to ietf-bgp {
    prefix bgp;
  }

  import ietf-routing-policy {
    prefix rt-pol;
    reference
      "RFC ZZZZ, A YANG Data Model for Routing Policy Management";
  }
  import iana-bgp-types {
    prefix bt;
    reference
      "RFC XXXX, BGP YANG Model for Service Provider Network.";
  }
  include ietf-bgp-common-multiprotocol;
  include ietf-bgp-common;

  // meta

  organization
    "IETF IDR Working Group";
  contact
    "WG Web:  <http://tools.ietf.org/wg/idr>
    WG List:  <idr@ietf.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
             Keyur Patel (keyur at arrcus.com),
             Susan Hares (shares at ndzh.com),
             Jeffrey Haas (jhaas at juniper.net).";

  description
    "This sub-module contains groupings that are common across
    multiple BGP contexts and provide structure around other
    primitive groupings.

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    authors of the code. All rights reserved.

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    Relating to IETF Documents
    (https://trustee.ietf.org/license-info).

    This version of this YANG module is part of RFC XXXX

```

(<https://www.rfc-editor.org/info/rfcXXXX>); see the RFC itself for full legal notices.

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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
```

```
    "Initial Version";
```

```
  reference
```

```
    "RFC XXX, BGP Model for Service Provider Network.";
```

```
}
```

```
grouping structure-neighbor-group-logging-options {
```

```
  description
```

```
    "Structural grouping used to include error handling
     configuration and state for both BGP neighbors and groups";
```

```
  container logging-options {
```

```
    description
```

```
      "Logging options for events related to the BGP neighbor or
       group";
```

```
  leaf log-neighbor-state-changes {
```

```
    type boolean;
```

```
    default "true";
```

```
    description
```

```
      "Configure logging of peer state changes. Default is to
       enable logging of peer state changes.
```

```

      Note: Documenting demotion from ESTABLISHED state is
            desirable, but documenting all backward transitions
            is problematic, and should be avoided.";
```

```
  }
```

```
}
```

```
}
```

```
grouping structure-neighbor-group-ebgp-multihop {
```

```
  description
```

```
    "Structural grouping used to include eBGP multi-hop
     configuration and state for both BGP neighbors and peer
     groups";
```

```
  container ebgp-multihop {
```

```
    description
```

```
      "eBGP multi-hop parameters for the BGP peer-group";
```

```
  leaf enabled {
```

```
    type boolean;
```

```
    default "false";
```

```

        description
            "When enabled, the referenced group or neighbors are
            permitted to be indirectly connected - including cases
            where the TTL can be decremented between the BGP peers";
    }
    leaf multihop-ttl {
        type uint8;
        description
            "Time-to-live value to use when packets are sent to the
            referenced group or neighbors and ebgp-multihop is
            enabled";
    }
}
}
}

```

```

grouping structure-neighbor-group-route-reflector {
    description
        "Structural grouping used to include route reflector
        configuration and state for both BGP neighbors and peer
        groups";
    container route-reflector {
        description
            "Route reflector parameters for the BGP peer-group";
        reference
            "RFC 4456: BGP Route Reflection.";
        leaf cluster-id {
            type bt:rr-cluster-id-type;
            description
                "Route Reflector cluster id to use when local router is
                configured as a route reflector. Commonly set at the
                group level, but allows a different cluster id to be set
                for each neighbor.";
            reference
                "RFC 4456: BGP Route Reflection: An Alternative to
                Full Mesh.";
        }
        leaf no-client-reflect {
            type boolean;
            default "false";
            description
                "When set to 'true', this disables route redistribution
                by the Route Reflector. It is set 'true' when the client
                is fully meshed in its peer-group to prevent sending of
                redundant route advertisements.";
        }
        leaf client {
            type boolean;
            default "false";
            description

```

```

        "Configure the neighbor as a route reflector client.";
    reference
        "RFC 4456: BGP Route Reflection: An Alternative to
            Full Mesh.";
    }
}

grouping structure-neighbor-group-as-path-options {
    description
        "Structural grouping used to include AS_PATH manipulation
            configuration and state for both BGP neighbors and peer
            groups";
    container as-path-options {
        description
            "AS_PATH manipulation parameters for the BGP neighbor or
                group";
        leaf allow-own-as {
            type uint8;
            default "0";
            description
                "Specify the number of occurrences of the local BGP
                    speaker's AS that can occur within the AS_PATH before it
                    is rejected as looped.";
        }
        leaf replace-peer-as {
            type boolean;
            default "false";
            description
                "Replace occurrences of the peer's AS in the AS_PATH with
                    the local autonomous system number";
        }
    }
}

grouping structure-neighbor-group-add-paths {
    description
        "Structural grouping used to include ADD-PATHs configuration
            and state for both BGP neighbors and peer groups";
    container add-paths {
        if-feature "bt:add-paths";
        description
            "Parameters relating to the advertisement and receipt of
                multiple paths for a single NLRI (add-paths)";
        reference
            "RFC 7911: Advertisements of Multiple Paths in BGP.";
        leaf receive {
            type boolean;
            default "false";
        }
    }
}

```

```

        description
            "Enable ability to receive multiple path advertisements for
            an NLRI from the neighbor or group";
    }
    choice send {
        description
            "Choice of sending the max. number of paths or to send
            all.";
        case max {
            leaf max {
                type uint8;
                description
                    "The maximum number of paths to advertise to neighbors
                    for a single NLRI";
            }
        }
        case all {
            leaf all {
                type empty;
                description
                    "Send all the path advertisements to neighbors for a
                    single NLRI.";
            }
        }
    }
    leaf eligible-prefix-policy {
        type leafref {
            path "/rt-pol:routing-policy/rt-pol:policy-definitions/"
                + "rt-pol:policy-definition/rt-pol:name";
        }
        description
            "A reference to a routing policy which can be used to
            restrict the prefixes for which add-paths is enabled";
    }
}
}
}

```

<CODE ENDS>

7.1.5. ietf-bgp-neighbors submodule

<CODE BEGINS> file "ietf-bgp-neighbor@2022-10-13.yang"

```
submodule ietf-bgp-neighbor {
  yang-version 1.1;
  belongs-to ietf-bgp {
    prefix bgp;
  }

  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 6991: Common YANG Data Types.";
  }

  import iana-bgp-types {
    prefix bt;
    reference
      "RFC XXXX, BGP Model for Service Provider Network.";
  }

  // Include the common submodule

  include ietf-bgp-common;
  include ietf-bgp-common-multiprotocol;
  include ietf-bgp-common-structure;

  // meta

  organization
    "IETF IDR Working Group";
  contact
    "WG Web:  <http://tools.ietf.org/wg/idr>
    WG List:  <idr@ietf.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
             Keyur Patel (keyur at arrcus.com),
             Susan Hares (shares at ndzh.com),
             Jeffrey Haas (jhaas at juniper.net).";

  description
    "This sub-module contains groupings that are specific to the
    neighbor context of the BGP module.

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    authors of the code. All rights reserved.

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```

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(<https://trustee.ietf.org/license-info>).

This version of this YANG module is part of RFC XXXX
(<https://www.rfc-editor.org/info/rfcXXXX>); see the RFC itself
for full legal notices.

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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
    "Initial Version";
  reference
    "RFC XXX, BGP Model for Service Provider Network.";
}

grouping bgp-neighbor-use-multiple-paths {
  description
    "Multi-path configuration and state applicable to a BGP
    neighbor";
  container use-multiple-paths {
    description
      "Parameters related to the use of multiple-paths for the same
      NLRI when they are received only from this neighbor";
    leaf enabled {
      type boolean;
      default "false";
      description
        "Whether the use of multiple paths for the same NLRI is
        enabled for the neighbor.";
    }
    container ebgp {
      description
        "Multi-path configuration for eBGP";
      leaf allow-multiple-as {
        type boolean;
        default "false";
        description
          "Allow multi-path to use paths from different neighboring
          ASes. The default is to only consider multiple paths
          from the same neighboring AS.";
      }
    }
  }
}
```



```

grouping bgp-neighbor-counters-message-types-state {
  description
    "Grouping of BGP message types, included for re-use across
    counters";
  leaf updates-received {
    type yang:zero-based-counter64;
    description
      "Number of BGP UPDATE messages received from this neighbor.";
    reference
      "RFC 4273: bgpPeerInUpdates.";
  }
  leaf updates-sent {
    type yang:zero-based-counter64;
    description
      "Number of BGP UPDATE messages sent to this neighbor";
    reference
      "RFC 4273 - bgpPeerOutUpdates";
  }
  leaf messages-received {
    type yang:zero-based-counter64;
    description
      "Number of BGP messages received from thsi neighbor";
    reference
      "RFC 4273 - bgpPeerInTotalMessages";
  }
  leaf messages-sent {
    type yang:zero-based-counter64;
    description
      "Number of BGP messages received from thsi neighbor";
    reference
      "RFC 4273 - bgpPeerOutTotalMessages";
  }
  leaf notification {
    type yang:zero-based-counter64;
    description
      "Number of BGP NOTIFICATION messages indicating an error
      condition has occurred exchanged.";
  }
}

```

```

grouping bgp-neighbor-afi-safi-list {
  description
    "List of address-families associated with the BGP neighbor";
  list afi-safi {
    key "name";
    description
      "AFI, SAFI configuration available for the neighbor or
      group";
  }
}

```

```

uses mp-afi-safi-config;
leaf active {
    type boolean;
    config false;
    description
        "This value indicates whether a particular AFI-SAFI has
        been successfully negotiated with the peer. An AFI-SAFI
        may be enabled in the current running configuration, but
        a session restart may be required in order to negotiate
        the new capability.";
}
container prefixes {
    config false;
    description
        "Prefix counters for the AFI/SAFI in this BGP session";
    leaf received {
        type yang:counter32;
        description
            "The number of prefixes received from the neighbor";
    }
    leaf sent {
        type yang:counter32;
        description
            "The number of prefixes advertised to the neighbor";
    }
    leaf installed {
        type yang:counter32;
        description
            "The number of advertised prefixes installed in the
            Loc-RIB";
    }
}
container graceful-restart {
    if-feature "bt:graceful-restart";
    description
        "Parameters relating to BGP graceful-restart";
    uses mp-afi-safi-graceful-restart-config;
    leaf received {
        type boolean;
        config false;
        description
            "This leaf indicates whether the neighbor advertised the
            ability to support graceful-restart for this AFI-SAFI";
    }
    leaf advertised {
        type boolean;
        config false;
        description
            "This leaf indicates whether the ability to support

```

```

        graceful-restart has been advertised to the peer";
    }
    leaf local-forwarding-state-preserved {
        type boolean;
        config false;
        description
            "This leaf indicates whether the local router has
            or would advertise the Forwarding State bit in its
            Graceful Restart capability for this AFI-SAFI.";
        reference
            "RFC 4724: Graceful Restart Mechanism for BGP.";
    }
    leaf forwarding-state-preserved {
        type boolean;
        config false;
        description
            "This leaf indicates whether the neighbor has advertised
            the Forwarding State bit in its Graceful Restart
            capability for this AFI-SAFI.";
        reference
            "RFC 4724: Graceful Restart Mechanism for BGP.";
    }
    leaf end-of-rib-received {
        type boolean;
        config false;
        description
            "This leaf indicates whether the neighbor has advertised
            the End-of-RIB marker for this AFI-SAFI.";
        reference
            "RFC 4724: Graceful Restart Mechanism for BGP.";
    }
}
uses mp-all-afi-safi-list-contents;
uses bgp-neighbor-use-multiple-paths;
}
}
}

```

<CODE ENDS>

7.2. BGP types module

<CODE BEGINS> file "iana-bgp-types@2022-10-13.yang"

```
module iana-bgp-types {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:iana-bgp-types";
  prefix bt;

  import ietf-inet-types {
    prefix inet;
  }

  // meta

  organization
    "IANA";
  contact
    "Internet Assigned Numbers Authority

    Postal: ICANN
           12025 Waterfront Drive, Suite 300
           Los Angeles, CA 90094-2536
           United States of America
    Tel:   +1 310 301 5800
    <mailto:iana@iana.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
            Keyur Patel (keyur at arrcus.com),
            Susan Hares (shares at ndzh.com),
            Jeffrey Haas (jhaas at juniper.net).";

  description
    "This module contains general data definitions for use in BGP.
    It can be imported by modules that make use of BGP attributes.

    This YANG module is maintained by IANA and reflects the
    'BGP Identities for Community' and 'BGP definitions for
    Community type' registries.

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    Relating to IETF Documents
    (https://trustee.ietf.org/license-info).

    This version of this YANG module is part of RFC XXXX
    (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
```

for full legal notices.

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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
    "Initial Version";
  reference
    "RFC XXX, BGP Model for Service Provider Network.";
}

/*
 * Features.
 */
feature add-paths {
  description
    "Advertisement of multiple paths for the same address prefix
    without the new paths implicitly replacing any previous
    ones.";
  reference
    "RFC 7911: Advertisement of Multiple Paths in BGP.";
}

feature bfd {
  description
    "Support for BFD detection of BGP neighbor reachability.";
  reference
    "RFC 5880, Bidirectional Forward Detection (BFD),
    RFC 5881, Bidirectional Forward Detection for IPv4 and IPv6
    (Single Hop),
    RFC 5883, Bidirectional Forwarding Detection (BFD) for
    Multihop Paths.";
}

feature clear-neighbors {
  description
    "Clearing of BGP neighbors is supported.";
}

feature clear-statistics {
  description
    "Clearing of BGP statistics is supported.";
}

feature clear-routes {
```

```

    description
        "Clearing of BGP routes is supported.";
}

feature damping {
    description
        "Weighted route dampening is supported.";
}

feature graceful-restart {
    description
        "Graceful restart as defined in RFC 4724 is supported.";
}

feature route-refresh {
    description
        "Support for the BGP Route Refresh capability.";
    reference
        "RFC 2918: Route Refresh Capability for BGP-4.";
}

feature send-communities {
    description
        "Enable the propagation of communities.";
}

feature ttl-security {
    description
        "BGP Time To Live (TTL) security check support.";
    reference
        "RFC 5082, The Generalized TTL Security Mechanism (GTSM).";
}

/*
 * Identities.
 */

identity bgp-capability {
    description
        "Base identity for a BGP capability";
}

identity mp-bgp {
    base bgp-capability;
    description
        "Multi-protocol extensions to BGP";
    reference
        "RFC 4760: Multiprotocol Extensions for BGP-4.";
}

```

```

identity route-refresh {
    base bgp-capability;
    description
        "The BGP route-refresh functionality";
    reference
        "RFC 2918: Route Refresh Capability for BGP-4.";
}

identity asn32 {
    base bgp-capability;
    description
        "4-byte (32-bit) AS number functionality";
    reference
        "RFC6793: BGP Support for Four-Octet Autonomous System (AS)
        Number Space.";
}

identity graceful-restart {
    if-feature "graceful-restart";
    base bgp-capability;
    description
        "Graceful restart functionality";
    reference
        "RFC 4724: Graceful Restart Mechanism for BGP.";
}

identity add-paths {
    if-feature "add-paths";
    base bgp-capability;
    description
        "Advertisement of multiple paths for the same address prefix
        without the new paths implicitly replacing any previous
        ones.";
    reference
        "RFC 7911: Advertisement of Multiple Paths in BGP.";
}

identity afi-safi-type {
    description
        "Base identity type for AFI,SAFI tuples for BGP-4";
    reference
        "RFC4760: Multiprotocol Extensions for BGP-4";
}

identity ipv4-unicast {
    base afi-safi-type;
    description
        "IPv4 unicast (AFI,SAFI = 1,1)";
    reference

```



```

    "RFC4760: Multiprotocol Extentions for BGP-4";
}

identity ipv6-unicast {
    base afi-safi-type;
    description
        "IPv6 unicast (AFI,SAFI = 2,1)";
    reference
        "RFC4760: Multiprotocol Extentions for BGP-4";
}

identity ipv4-labeled-unicast {
    base afi-safi-type;
    description
        "Labeled IPv4 unicast (AFI,SAFI = 1,4)";
    reference
        "RFC 8277: Using BGP to Bind MPLS Labels to Address Prefixes.";
}

identity ipv6-labeled-unicast {
    base afi-safi-type;
    description
        "Labeled IPv6 unicast (AFI,SAFI = 2,4)";
    reference
        "RFC 8277: Using BGP to Bind MPLS Labels to Address Prefixes.";
}

identity l3vpn-ipv4-unicast {
    base afi-safi-type;
    description
        "Unicast IPv4 MPLS L3VPN (AFI,SAFI = 1,128)";
    reference
        "RFC 4364: BGP/MPLS IP Virtual Private Networks (VPNs).";
}

identity l3vpn-ipv6-unicast {
    base afi-safi-type;
    description
        "Unicast IPv6 MPLS L3VPN (AFI,SAFI = 2,128)";
    reference
        "RFC 4659: BGP/MPLS IP Virtual Private Network (VPN) Extension
            for IPv6 VPN.";
}

identity l3vpn-ipv4-multicast {
    base afi-safi-type;
    description
        "Multicast IPv4 MPLS L3VPN (AFI,SAFI = 1,129)";
    reference

```

```

        "RFC 6514: BGP Encodings and Procedures for Multicast in
          MPLS/BGP IP VPNs.";
    }

    identity l3vpn-ipv6-multicast {
        base afi-safi-type;
        description
            "Multicast IPv6 MPLS L3VPN (AFI,SAFI = 2,129)";
        reference
            "RFC 6514: BGP Encodings and Procedures for Multicast in
              MPLS/BGP IP VPNs.";
    }

    identity l2vpn-vpls {
        base afi-safi-type;
        description
            "BGP-signalled VPLS (AFI,SAFI = 25,65)";
        reference
            "RFC 4761: Virtual Private LAN Service (VPLS) Using BGP for
              Auto-Discovery and Signaling.";
    }

    identity l2vpn-evpn {
        base afi-safi-type;
        description
            "BGP MPLS Based Ethernet VPN (AFI,SAFI = 25,70)";
    }

    identity bgp-well-known-std-community {
        description
            "Base identity for reserved communities within the standard
              community space defined by RFC 1997. These communities must
              fall within the range 0xFFFF0000 to 0xFFFFFFFF";
        reference
            "RFC 1997: BGP Communities Attribute.";
    }

    identity no-export {
        base bgp-well-known-std-community;
        description
            "Do not export NLRI received carrying this community outside
              the bounds of this autonomous system, or this confederation
              (if the local autonomous system is a confederation member AS).
              This community has a value of 0xFFFFF01.";
        reference
            "RFC 1997: BGP Communities Attribute.";
    }

    identity no-advertise {

```

```

base bgp-well-known-std-community;
description
    "All NLRI received carrying this community must not be
    advertised to other BGP peers. This community has a value of
    0xFFFFFFFF02.";
reference
    "RFC 1997: BGP Communities Attribute.";
}

identity no-export-subconfed {
    base bgp-well-known-std-community;
    description
        "All NLRI received carrying this community must not be
        advertised to external BGP peers - including over
        confederation sub-AS boundaries. This community has a value of
        0xFFFFFFFF03.";
    reference
        "RFC 1997: BGP Communities Attribute.";
}

identity no-peer {
    base bgp-well-known-std-community;
    description
        "An autonomous system receiving NLRI tagged with this community
        is advised not to re-advertise the NLRI to external bilateral
        peer autonomous systems. An AS may also filter received NLRI
        from bilateral peer sessions when they are tagged with this
        community value. This community has a value of 0xFFFFFFFF04.";
    reference
        "RFC 3765: NOPEER Community for BGP.";
}

identity as-path-segment-type {
    description
        "Base AS Path Segment Type. In [BGP-4], the path segment type
        is a 1-octet field with the following values defined.";
    reference
        "RFC 4271: A Border Gateway Protocol 4 (BGP-4), Section 4.3.";
}

identity as-set {
    base as-path-segment-type;
    description
        "Unordered set of autonomous systems that a route in the UPDATE
        message has traversed.";
    reference
        "RFC 4271: A Border Gateway Protocol 4 (BGP-4), Section 4.3.";
}

```

```
identity as-sequence {
    base as-path-segment-type;
    description
        "Ordered set of autonomous systems that a route in the UPDATE
        message has traversed.";
    reference
        "RFC 4271: A Border Gateway Protocol 4 (BGP-4), Section 4.3.";
}
```

```
identity as-confed-sequence {
    base as-path-segment-type;
    description
        "Ordered set of Member Autonomous Systems in the local
        confederation that the UPDATE message has traversed.";
    reference
        "RFC 5065, Autonomous System Configuration for BGP.";
}
```

```
identity as-confed-set {
    base as-path-segment-type;
    description
        "Unordered set of Member Autonomous Systems in the local
        confederation that the UPDATE message has traversed.";
    reference
        "RFC 5065, Autonomous System Configuration for BGP.";
}
```

```
identity send-community-feature {
    description
        "Base identity to identify send-community feature.";
}
```

```
identity standard {
    base send-community-feature;
    description
        "Send standard communities.";
    reference
        "RFC 1997: BGP Communities Attribute.";
}
```

```
identity extended {
    base send-community-feature;
    description
        "Send extended communities.";
    reference
        "RFC 4360: BGP Extended Communities Attribute.";
}
```

```
identity large {
```

```

base send-community-feature;
description
    "Send large communities.";
reference
    "RFC 8092: BGP Large Communities Attribute.";
}

/*
 * Typedefs.
 */

typedef bgp-session-direction {
    type enumeration {
        enum inbound {
            description
                "Refers to all NLRI received from the BGP peer";
        }
        enum outbound {
            description
                "Refers to all NLRI advertised to the BGP peer";
        }
    }
    description
        "Type to describe the direction of NLRI transmission";
}

typedef bgp-well-known-community-type {
    type identityref {
        base bgp-well-known-std-community;
    }
    description
        "Type definition for well-known IETF community attribute
        values.";
    reference
        "IANA Border Gateway Protocol (BGP) Well Known Communities";
}

typedef bgp-std-community-type {
    type union {
        type uint32;
        type string {
            pattern '([0-9]|[1-9][0-9]{1,3}|[1-5][0-9]{4}|'
                + '6[0-5][0-9]{3}|66[0-4][0-9]{2}|'
                + '665[0-2][0-9]|6653[0-5]):'
                + '([0-9]|[1-9][0-9]{1,3}|[1-5][0-9]{4}|'
                + '6[0-5][0-9]{3}|66[0-4][0-9]{2}|'
                + '665[0-2][0-9]|6653[0-5]))';
        }
    }
}

```

```

description
    "Type definition for standard community attributes.";
reference
    "RFC 1997 - BGP Communities Attribute";
}

typedef bgp-ext-community-type {
    type union {
        type string {
            // Type 1: 2-octet global and 4-octet local
            //          (AS number)          (Integer)
            pattern '(6[0-5][0-5][0-3][0-5]|[1-5][0-9]{4}|'
                + '[1-9][0-9]{1,4}|[0-9]):'
                + '(4[0-2][0-9][0-4][0-9][0-6][0-7][0-2][0-9][0-6]|'
                + '[1-3][0-9]{9}|[1-9]([0-9]{1,7})?[0-9]|[1-9])';
        }

        type string {
            // Type 2: 4-octet global and 2-octet local
            //          (ipv4-address)      (integer)
            pattern '((([0-9]|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|'
                + '25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9][0-9]|'
                + '2[0-4][0-9]|25[0-5])):'
                + '(6[0-5][0-5][0-3][0-5]|[1-5][0-9]{4}|'
                + '[1-9][0-9]{1,4}|[0-9])';
        }

        type string {
            // route-target with Type 1
            // route-target:(ASN):(local-part)
            // 2 octets global and 4 octets local.
            pattern 'route\-target:(6[0-5][0-5][0-3][0-5]|'
                + '[1-5][0-9]{4}|[1-9][0-9]{1,4}|[0-9]):'
                + '(4[0-2][0-9][0-4][0-9][0-6][0-7][0-2][0-9][0-6]|'
                + '[1-3][0-9]{9}|[1-9]([0-9]{1,7})?[0-9]|[1-9])';
        }

        type string {
            // route-target with Type 2
            // route-target:(IPv4):(local-part)
            // 4 bytes of IP address, and 2 bytes for local.
            pattern 'route\-target:'
                + '((([0-9]|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|'
                + '25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9][0-9]|'
                + '2[0-4][0-9]|25[0-5])):'
                + '(6[0-5][0-5][0-3][0-5]|[1-5][0-9]{4}|'
                + '[1-9][0-9]{1,4}|[0-9])';
        }
    }
}

```

```

type string {
    // route-origin with Type 1
    // All 6 octets are open.
    pattern 'route\-origin:(6[0-5][0-5][0-3][0-5]|'
        + '[1-5][0-9]{4}|[1-9][0-9]{1,4}|[0-9]):'
        + '(4[0-2][0-9][0-4][0-9][0-6][0-7][0-2][0-9][0-6]|'
        + '[1-3][0-9]{9}|[1-9]([0-9]{1,7})?[0-9]|[1-9])';
}

type string {
    // route-origin with Type 2
    // 4 octets of IP address and two octets of local.
    pattern 'route\-origin:'
        + '(([0-9]|[1-9][0-9]|1[0-9][0-9]|2[0-4][0-9]|'
        + '25[0-5])\.){3}([0-9]|[1-9][0-9]|1[0-9][0-9]|'
        + '2[0-4][0-9]|25[0-5]):'
        + '(6[0-5][0-5][0-3][0-5]|[1-5][0-9]{4}|'
        + '[1-9][0-9]{1,4}|[0-9])';
}

type string {
    // raw with 8 octets
    pattern 'raw:([0-9A-F][0-9A-F]){7}[0-9A-F][0-9A-F]';
}
}
description
    "Type definition for extended community attributes.
    It includes a way to specify a 'raw' string that
    is followed by 8 bytes of octet string to support
    new and experimental type definitions.";
reference
    "RFC 4360 - BGP Extended Communities Attribute";
}

typedef bgp-community-regexp-type {
    type string;
    description
        "Type definition for communities specified as regular
        expression patterns";
}

typedef bgp-origin-attr-type {
    type enumeration {
        enum igp {
            description
                "Origin of the NLRI is internal";
        }
        enum egp {
            description

```

```

        "Origin of the NLRI is EGP";
    }
    enum incomplete {
        description
            "Origin of the NLRI is neither IGP or EGP";
    }
}
description
    "Type definition for standard BGP origin attribute";
reference
    "RFC 4271 - A Border Gateway Protocol 4 (BGP-4), Sec 4.3";
}

typedef bgp-large-community-type {
    type string {
        // 4-octets global:4-octets local part-1:4-octets local part-2.
        pattern '(4[0-2][0-9][0-4][0-9][0-6][0-7][0-2][0-9][0-6]||'
            + '[1-3][0-9]{9}|[1-9]([0-9]{1,7})?[0-9]|[1-9]):'
            + '(4[0-2][0-9][0-4][0-9][0-6][0-7][0-2][0-9][0-6]||'
            + '[1-3][0-9]{9}|[1-9]([0-9]{1,7})?[0-9]|[1-9]):'
            + '(4[0-2][0-9][0-4][0-9][0-6][0-7][0-2][0-9][0-6]||'
            + '[1-3][0-9]{9}|[1-9]([0-9]{1,7})?[0-9]|[1-9])';
    }
    description
        "Type definition for a large BGP community";
    reference
        "RFC 8092: BGP Large Communities Attribute.";
}

typedef peer-type {
    type enumeration {
        enum internal {
            description
                "Internal (IBGP) peer";
        }
        enum external {
            description
                "External (EBGP) peer";
        }
        enum confederation-internal {
            description
                "Confederation Internal (IBGP) peer.";
        }
        enum confederation-external {
            description
                "Confederation External (EBGP) peer.";
        }
    }
}
description

```



```

        "Labels a peer or peer group as explicitly internal,
        external, or the related confederation type.";
reference
    "RFC 4271 - A Border Gateway Protocol 4 (BGP-4), Sec 1.1.
    RFC 5065, Autonomous System Configuration for BGP.";
}

identity remove-private-as-option {
    description
        "Base identity for options for removing private autonomous
        system numbers from the AS_PATH attribute";
}

identity private-as-remove-all {
    base remove-private-as-option;
    description
        "Strip all private autonomous system numbers from the AS_PATH.
        This action is performed regardless of the other content of
        the AS_PATH attribute, and for all instances of private AS
        numbers within that attribute.";
}

identity private-as-replace-all {
    base remove-private-as-option;
    description
        "Replace all instances of private autonomous system numbers in
        the AS_PATH with the local BGP speaker's autonomous system
        number. This action is performed regardless of the other
        content of the AS_PATH attribute, and for all instances of
        private AS number within that attribute.";
}

typedef remove-private-as-option {
    type identityref {
        base remove-private-as-option;
    }
    description
        "Set of options for configuring how private AS path numbers
        are removed from advertisements";
}

typedef rr-cluster-id-type {
    type union {
        type uint32;
        type inet:ipv4-address;
    }
    description
        "Union type for route reflector cluster ids:
        option 1: 4-byte number

```

```
        option 2: IP address";  
    }  
}  
  
<CODE ENDS>
```

7.3. BGP policy module

<CODE BEGINS> file "ietf-bgp-policy@2022-10-13.yang"

```
module ietf-bgp-policy {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-bgp-policy";
  prefix bp;

  // import some basic types

  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991: Common YANG Data Types";
  }
  import ietf-routing-policy {
    prefix rt-pol;
    reference
      "RFC 9067: A YANG Data Model for Routing Policy";
  }
  import iana-bgp-types {
    prefix bt;
  }
  import ietf-routing-types {
    prefix rt-types;
    reference
      "RFC 8294 - Common YANG Data Types for the
        Routing Area";
  }

  organization
    "IETF IDR Working Group";
  contact
    "WG Web:  <http://datatracker.ietf.org/wg/idr>
    WG List:  <idr@ietf.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
             Keyur Patel (keyur at arccus.com),
             Susan Hares (shares at ndzh.com),
             Jeffrey Haas (jhaas at juniper.net).";

  description
    "This module contains data definitions for BGP routing policy.
    It augments the base routing-policy module with BGP-specific
    options for conditions and actions.

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    authors of the code. All rights reserved.

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    without modification, is permitted pursuant to, and subject to
```

the license terms contained in, the Revised BSD License set forth in Section 4.c of the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>).

This version of this YANG module is part of RFC XXXX (<https://www.rfc-editor.org/info/rfcXXXX>); see the RFC itself for full legal notices.

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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
    "Initial Version";
  reference
    "RFC XXX, BGP Model for Service Provider Network.";
}

/*
 * typedef statements
 */

typedef bgp-set-community-option-type {
  type enumeration {
    enum add {
      description
        "Add the specified communities to the existing
        community attribute.";
    }
    enum remove {
      description
        "Remove the specified communities from the
        existing community attribute.";
    }
    enum replace {
      description
        "Replace the existing community attribute with
        the specified communities. If an empty set is
        specified, this removes the community attribute
        from the route.";
    }
  }
}
description
  "Type definition for options when setting the community
  attribute in a policy action.";
```

```

}

typedef bgp-next-hop-type {
    type union {
        type inet:ip-address-no-zone;
        type enumeration {
            enum self {
                description
                "Special designation for local router's own
                address, i.e., next-hop-self.";
            }
        }
    }
}
description
    "Type definition for specifying next-hop in policy actions.";
}

typedef bgp-set-med-type {
    type union {
        type string {
            pattern '[+ -]([0-9]{1,8}|[0-3][0-9]{1,9}|4[0-1][0-9]{1,8}|'
                + '428[0-9]{1,7}|429[0-3][0-9]{1,6}|42948[0-9]{1,5}|'
                + '42949[0-5][0-9]{1,4}|429496[0-6][0-9]{1,3}|'
                + '4294971[0-9]{1,2}|42949728[0-9]|42949729[0-5])';
        }
        type enumeration {
            enum igp {
                description
                "Set the MED value to the IGP cost toward the
                next hop for the route.";
            }
            enum med-plus-igp {
                description
                "Before comparing MED values for path selection, adds to
                the MED the cost of the IGP route to the BGP next-hop
                destination.

                This option replaces the MED value for the router,
                but does not affect the IGP metric comparison. As a
                result, when multiple routes have the same value
                after the MED-plus-IPG comparison, and route selection
                continues, the IGP route metric is also compared, even
                though it was added to the MED value and compared
                earlier in the selection process.

                Useful when the downstream AS requires the complete
                cost of a certain route that is received across
                multiple ASs.";
            }
        }
    }
}

```

```

    }
    type uint32;
}
description
    "Type definition for specifying how the BGP MED can
    be set in BGP policy actions. The three choices are to set
    the MED directly, increment/decrement using +/- notation,
    and setting it to the IGP cost (predefined value).";
}

// Identities

// augment statements

augment "/rt-pol:routing-policy/rt-pol:defined-sets" {
    description
        "Adds BGP defined sets container to routing policy model.";
    container bgp-defined-sets {
        description
            "BGP-related set definitions for policy match conditions.";
        container community-sets {
            description
                "Enclosing container for list of defined BGP community
                sets.";
            list community-set {
                key "name";
                description
                    "List of defined BGP community sets.";
                leaf name {
                    type string;
                    description
                        "Name / label of the community set -- this is used to
                        reference the set in match conditions.";
                }
                leaf-list member {
                    type union {
                        type bt:bgp-well-known-community-type;
                        type bt:bgp-std-community-type;
                        type bt:bgp-community-regexp-type;
                    }
                    description
                        "Members of the community set";
                }
            }
        }
    }
}

container ext-community-sets {
    description
        "Enclosing container for list of extended BGP community

```

```

        sets";
list ext-community-set {
    key "name";
    description
        "List of defined extended BGP community sets";
    leaf name {
        type string;
        description
            "Name / label of the extended community set -- this is
            used to reference the set in match conditions";
    }
    leaf-list member {
        type union {
            type rt-types:route-target;
            type bt:bgp-community-regexp-type;
        }
        description
            "Members of the extended community set.";
    }
}
}
}

```

```

container large-community-sets {
    description
        "Enclosing container for list of large BGP community
        sets";
    list large-community-set {
        key "name";
        description
            "List of defined large BGP community sets";
        leaf name {
            type string;
            description
                "Name / label of the large community set -- this is
                used to reference the set in match conditions";
        }
        leaf-list member {
            type union {
                type bt:bgp-large-community-type;
                type bt:bgp-community-regexp-type;
            }
            description
                "Members of the large community set.";
        }
    }
}
}
}

```

```

container as-path-sets {
    description

```



```

    "Enclosing container for list of define AS path sets.";
  list as-path-set {
    key "name";
    description
      "List of defined AS path sets.";
    leaf name {
      type string;
      description
        "Name of the AS path set -- this is used to reference
        the set in match conditions.";
    }
    leaf-list member {
      type string;
      description
        "AS path regular expression -- list of ASes in the
        set. If any of the regular expression in the lists
        is matched, the as-path-set is considered matched.";
    }
  }
}

container next-hop-sets {
  description
    "Definition of a list of IPv4 or IPv6 next-hops which can
    be matched in a routing policy.";

  list next-hop-set {
    key "name";
    description
      "List of defined next-hop sets for use in policies.";

    leaf name {
      type string;
      description
        "Name of the next-hop set.";
    }
    leaf-list next-hop {
      type bgp-next-hop-type;
      description
        "List of IP addresses in the next-hop set.";
    }
  }
}

}

augment "/rt-pol:routing-policy/rt-pol:policy-definitions/" +
  "rt-pol:policy-definition/rt-pol:statements/" +
  "rt-pol:statement/rt-pol:conditions" {

```

```

description
    "BGP policy conditions added to routing policy module.";

container bgp-conditions {
    description
        "Top-level container for BGP specific policy conditions.";

    leaf med-eq {
        type uint32;
        description
            "Condition to check if the received MED value is equal to
            the specified value.";
    }

    leaf origin-eq {
        type bt:bgp-origin-attr-type;
        description
            "Condition to check if the route origin is equal to the
            specified value.";
    }
}

container match-afi-safi {
    description
        "Match an address family according to the logic defined in
        the match-set-options leaf.";
    leaf-list afi-safi-in {
        type identityref {
            base bt:afi-safi-type;
        }
        description
            "List of address families which the NLRI may be within.";
    }
    uses rt-pol:match-set-options-restricted-group;
}

leaf local-pref-eq {
    type uint32;
    description
        "Condition to check if the local pref attribute is equal to
        the specified value.";
}

container match-neighbor {
    description
        "Match a neighbor according to the logic defined in the
        match-set-options leaf.";

    leaf-list neighbor-eq {
        type inet:ip-address;
    }
}

```

```

        description
            "List of neighbor addresses to check for in the ingress
            direction.";
    }
    uses rt-pol:match-set-options-restricted-group;
}

leaf route-type {
    type enumeration {
        enum internal {
            description
                "route type is internal.";
        }
        enum external {
            description
                "route type is external.";
        }
    }
    description
        "Condition to check the route type in the route update.";
}

container community-count {
    description
        "Value and comparison operations for conditions based on
        the number of communities in the route update.";

    leaf community-count {
        type uint32;
        description
            "Value for the number of communities in the route
            update.";
    }

    choice operation {
        case eq {
            leaf eq {
                type empty;
                description
                    "Check to see if the value is equal.";
            }
        }

        case lt-or-eq {
            leaf lt-or-eq {
                type empty;
                description
                    "Check to see if the value is less than or equal.";
            }
        }
    }
}

```

```

    }

    case gt-or-eq {
        leaf gt-or-eq {
            type empty;
            description
                "Check to see if the value is greater than or
                equal.";
        }
    }
    description
        "Choice of operations on the value of community-count.";
}

container as-path-length {
    description
        "Value and comparison operations for conditions based on
        the length of the AS path in the route update.

        The as-path-length SHALL be calculated and SHALL follow
        RFC 4271 rules.";
    reference
        "RFC 4271: BGP-4.";

    leaf as-path-length {
        type uint32;
        description
            "Value of the AS path length in the route update.";
    }

    choice operation {
        case eq {
            leaf eq {
                type empty;
                description
                    "Check to see if the value is equal.";
            }
        }

        case lt-or-eq {
            leaf lt-or-eq {
                type empty;
                description
                    "Check to see if the value is less than or equal.";
            }
        }

        case gt-or-eq {

```

```

        leaf gt-or-eq {
            type empty;
            description
                "Check to see if the value is greater than or
                equal.";
        }
    }
    description
        "Choice of operations on the value of as-path-len.";
}
}

container match-community-set {
    description
        "Top-level container for match conditions on communities.
        Match a referenced community-set according to the logic
        defined in the match-set-options leaf.";
    leaf community-set {
        type leafref {
            path "/rt-pol:routing-policy/rt-pol:defined-sets/"
                + "bgp-defined-sets/community-sets/"
                + "community-set/name";
        }
        description
            "References a defined community set.";
    }
    uses rt-pol:match-set-options-group;
}

container match-ext-community-set {
    description
        "Match a referenced extended community-set according to the
        logic defined in the match-set-options leaf.";
    leaf ext-community-set {
        type leafref {
            path "/rt-pol:routing-policy/rt-pol:defined-sets/"
                + "bgp-defined-sets/ext-community-sets/"
                + "ext-community-set/name";
        }
        description
            "References a defined extended community set.";
    }
    uses rt-pol:match-set-options-group;
}

container match-large-community-set {
    description
        "Match a referenced large community-set according to the
        logic defined in the match-set-options leaf.";
}

```

```

leaf large-community-set {
    type leafref {
        path "/rt-pol:routing-policy/rt-pol:defined-sets/"
            + "bgp-defined-sets/large-community-sets/"
            + "large-community-set/name";
    }
    description
        "References a defined large community set.";
}
uses rt-pol:match-set-options-group;
}

container match-as-path-set {
    description
        "Match a referenced as-path set according to the logic
        defined in the match-set-options leaf.";
    leaf as-path-set {
        type leafref {
            path "/rt-pol:routing-policy/rt-pol:defined-sets/"
                + "bgp-defined-sets/as-path-sets/"
                + "as-path-set/name";
        }
        description
            "References a defined AS path set";
    }
    uses rt-pol:match-set-options-group;
}

container match-next-hop-set {
    description
        "Match a referenced next-hop set according to the logic
        defined in the match-set-options leaf.";
    leaf next-hop-set {
        type leafref {
            path "/rt-pol:routing-policy/rt-pol:defined-sets/"
                + "bgp-defined-sets/next-hop-sets/"
                + "next-hop-set/name";
        }
        description
            "Reference a defined next-hop set.";
    }
    uses rt-pol:match-set-options-restricted-group;
}
}

augment "/rt-pol:routing-policy/rt-pol:policy-definitions/" +
    "rt-pol:policy-definition/rt-pol:statements/" +
    "rt-pol:statement/rt-pol:actions" {

```

```

description
  "BGP policy actions added to routing policy module.";
container bgp-actions {
  description
    "Top-level container for BGP-specific actions";
  leaf set-route-origin {
    type bt:bgp-origin-attr-type;
    description
      "Set the origin attribute to the specified value";
  }
  leaf set-local-pref {
    type uint32;
    description
      "Set the local pref attribute on the route.";
  }
  leaf set-next-hop {
    type bgp-next-hop-type;
    description
      "Set the next-hop attribute in the route.";
  }
  leaf set-med {
    type bgp-set-med-type;
    description
      "Set the med metric attribute in the route.";
  }
}

container set-as-path-prepend {
  description
    "Action to prepend local AS number to the AS-path a
    specified number of times";

  leaf repeat-n {
    type uint8 {
      range "1..max";
    }
    description
      "Number of times to prepend the AS number to the AS
      path. The value should be between 1 and the maximum
      supported by the implementation.";
  }
  leaf-list asn {
    type inet:as-number;
    description
      "AS number to prepend to the AS path.";
  }
}

container set-community {
  description

```

"Action to set the community attributes of the route, along with options to modify how the community is modified. Communities may be set using an inline list OR reference to an existing defined set (not both).";

```
leaf options {  
  type bgp-set-community-option-type;  
  description  
    "Options for modifying the community attribute with  
    the specified values. These options apply to both  
    methods of setting the community attribute.";  
}
```

```
choice method {  
  description  
    "Indicates the method used to specify the extended  
    communities for the set-community action";  
  case inline {  
    leaf-list communities {  
      type union {  
        type bt:bgp-well-known-community-type;  
        type bt:bgp-std-community-type;  
      }  
      description  
        "Set the community values for the update inline with  
        a list.";  
    }  
  }  
}
```

```
case reference {  
  leaf community-set-ref {  
    type leafref {  
      path "/rt-pol:routing-policy/rt-pol:defined-sets/"  
        + "bgp-defined-sets/"  
        + "community-sets/community-set/name";  
    }  
    description  
      "References a defined community set by name";  
  }  
}  
}
```

```
container set-ext-community {  
  description  
    "Action to set the extended community attributes of the  
    route, along with options to modify how the community is  
    modified. Extended communities may be set using an inline  
    list OR a reference to an existing defined set (but not
```



```

        both).";

leaf options {
    type bgp-set-community-option-type;
    description
        "Options for modifying the community attribute with
        the specified values. These options apply to both
        methods of setting the community attribute.";
}

choice method {
    description
        "Indicates the method used to specify the extended
        communities for the set-ext-community action";
    case inline {
        leaf-list communities {
            type rt-types:route-target;
            description
                "Set the extended community values for the update
                inline with a list.";
        }
    }
    case reference {
        leaf ext-community-set-ref {
            type leafref {
                path "/rt-pol:routing-policy/rt-pol:defined-sets/"
                    + "bgp-defined-sets/ext-community-sets/"
                    + "ext-community-set/name";
            }
            description
                "References a defined extended community set by
                name.";
        }
    }
}

}

container set-large-community {
    description
        "Action to set the large community attributes of the
        route, along with options to modify how the community is
        modified. Large communities may be set using an inline
        list OR a reference to an existing defined set (but not
        both).";

    leaf options {
        type bgp-set-community-option-type;
        description
            "Options for modifying the community attribute with

```


7.4. RIB submodules

7.4.1. ietf-bgp-rib submodule

<CODE BEGINS> file "ietf-bgp-rib@2022-10-13.yang"

```
submodule ietf-bgp-rib {
  yang-version 1.1;
  belongs-to ietf-bgp {
    prefix br;
  }

  /*
   * Import and Include
   */

  import iana-bgp-types {
    prefix bt;
    reference
      "RFC XXXX: BGP YANG Model for Service Provider Networks.";
  }
  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991: Common YANG Types.";
  }
  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 6991: Common YANG Types.";
  }
  include ietf-bgp-rib-types;
  include ietf-bgp-rib-tables;

  // groupings of attributes in three categories:
  // - shared across multiple routes
  // - common to LOC-RIB and Adj-RIB, but not shared across routes
  // - specific to LOC-RIB or Adj-RIB
  // groupings of annotations for each route or table
  include ietf-bgp-rib-attributes;

  organization
    "IETF IDR Working Group";
  contact
    "WG Web:  <http://tools.ietf.org/wg/idr>
     WG List:  <idr@ietf.org>

     Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
              Keyur Patel (keyur at arrcus.com),
              Susan Hares (shares at ndzh.com),
              Jeffrey Haas (jhaas at juniper dot net).";

  description
```

"Defines a submodule for representing BGP routing table (RIB) contents. The submodule supports 5 logical RIBs per address family:

loc-rib: This is the main BGP routing table for the local routing instance, containing best-path selections for each prefix. The loc-rib table may contain multiple routes for a given prefix, with an attribute to indicate which was selected as the best path. Note that multiple paths may be used or advertised even if only one path is marked as best, e.g., when using BGP add-paths. An implementation may choose to mark multiple paths in the RIB as best path by setting the flag to true for multiple entries.

adj-rib-in-pre: This is a per-neighbor table containing the NLRI updates received from the neighbor before any local input policy rules or filters have been applied. This can be considered the 'raw' updates from a given neighbor.

adj-rib-in-post: This is a per-neighbor table containing the routes received from the neighbor that are eligible for best-path selection after local input policy rules have been applied.

adj-rib-out-pre: This is a per-neighbor table containing routes eligible for sending (advertising) to the neighbor before output policy rules have been applied.

adj-rib-out-post: This is a per-neighbor table containing routes eligible for sending (advertising) to the neighbor after output policy rules have been applied.

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This version of this YANG module is part of RFC XXXX (<https://www.rfc-editor.org/info/rfcXXXX>); see the RFC itself for full legal notices.

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 (RFC 2119) (RFC 8174) when, and only when,

```

    they appear in all capitals, as shown here.";

revision 2022-10-13 {
    description
        "Initial Version";
    reference
        "RFC XXXX, BGP YANG Model for Service Provider Network.";
}

grouping attr-set-attributes {
    description
        "A grouping for all attribute set parameters.";

    container attributes {
        description
            "A container for attribute set parameters.";

        leaf origin {
            type bt:bgp-origin-attr-type;
            description
                "BGP attribute defining the origin of the path
                information.";
        }
        leaf atomic-aggregate {
            type boolean;
            description
                "BGP attribute indicating that the prefix is an atomic
                aggregate; i.e., the peer selected is a less specific
                route without selecting a more specific route that is
                subsumed by it.";
            reference
                "RFC 4271: Section 5.1.6.";
        }
        leaf next-hop {
            type inet:ip-address;
            description
                "BGP next hop attribute defining the IP address of the
                router that should be used as the next hop to the
                destination.";
            reference
                "RFC 4271: Section 5.1.3.";
        }
        leaf link-local-next-hop {
            type inet:ipv6-address;
            description
                "When both a global and a link-local next-hop are sent
                when following RFC 2545 procedures, this leaf contains
                the link-local next-hop.";
            reference

```

```

        "RFC 2545: Use of BGP-4 Multiprotocol Extensions for IPv6
        Inter-Domain Routing";
    }
    leaf med {
        type uint32;
        description
            "BGP multi-exit discriminator attribute used in the BGP
            route selection process.";
        reference
            "RFC 4271: Section 5.1.4.";
    }
    leaf local-pref {
        type uint32;
        description
            "BGP local preference attribute sent to internal peers to
            indicate the degree of preference for externally learned
            routes. The route with the highest local preference
            value is preferred.";
        reference
            "RFC 4271: Section 5.1.5.";
    }
    leaf originator-id {
        type yang:dotted-quad;
        description
            "BGP attribute that provides the id as an IPv4 address
            of the originator of the announcement.";
        reference
            "RFC 4456 - BGP Route Reflection: An Alternative to Full
            Mesh Internal BGP (IBGP)";
    }
    leaf-list cluster-list {
        type yang:dotted-quad;
        description
            "Represents the reflection path that the route has
            passed.";
        reference
            "RFC 4456 - BGP Route Reflection: An Alternative to Full
            Mesh Internal BGP (IBGP)";
    }
    leaf aigp-metric {
        type uint64;
        description
            "BGP path attribute representing the accumulated IGP
            metric for the path";
        reference
            "RFC 7311 - The Accumulated IGP Metric Attribute for BGP";
    }
    container aggregator {
        config false;
    }

```



```

description
    "BGP attribute indicating the prefix has been
    aggregated by the specified AS and router.";
reference
    "RFC 4271: Section 5.1.7.
    RFC 6793 - BGP Support for Four-octet AS Number Space.";
leaf as {
    type inet:as-number;
    description
        "AS number of the autonomous system that performed the
        aggregation.";
}
leaf address {
    type inet:ipv4-address;
    description
        "IP address of the router that performed the
        aggregation.";
}
}
container aggregator4 {
    config false;
    description
        "BGP attribute indicating the prefix has been
        aggregated by the specified AS and router.
        This value is populated with the received or sent
        attribute in Adj-RIB-In or Adj-RIB-Out, respectively.
        It should not be populated in Loc-RIB since the Loc-RIB
        is expected to store the effective AGGREGATOR in the
        aggregator/as leaf regardless of being 4-octet or
        2-octet.";
    reference
        "RFC 4271: Section 5.1.7.";
    leaf as4 {
        type inet:as-number;
        description
            "AS number of the autonomous system that performed the
            aggregation (4-octet representation). This value is
            populated if an upstream router is not 4-octet capable.
            Its semantics are similar to the AS4_PATH optional
            transitive attribute";
        reference
            "RFC 6793 - BGP Support for Four-octet AS Number Space";
    }
    leaf address {
        type inet:ipv4-address;
        description
            "IP address of the router that performed the
            aggregation.";
    }
}

```

```

}
container as-path {
  description
    "Enclosing container for the list of AS path segments.

    In the Adj-RIB-In or Adj-RIB-Out, this list should show
    the received or sent AS_PATH, respectively. For
    example, if the local router is not 4-byte capable, this
    value should consist of 2-octet ASNs or the AS_TRANS
    (AS 23456) values received or sent in route updates.

    In the Loc-RIB, this list should reflect the effective
    AS path for the route, e.g., a 4-octet value if the
    local router is 4-octet capable.";
  reference
    "RFC 4271 - A Border Gateway Protocol 4 (BGP-4)
    RFC 6793 - BGP Support for Four-octet AS Number Space
    RFC 5065 - Autonomous System Confederations for BGP";
  list segment {
    config false;
    uses bgp-as-path-attr;
    description
      "List of AS PATH segments";
  }
}
container as4-path {
  description
    "This is the path encoded with 4-octet
    AS numbers in the optional transitive AS4_PATH attribute.
    This value is populated with the received or sent
    attribute in Adj-RIB-In or Adj-RIB-Out, respectively.
    It should not be populated in Loc-RIB since the Loc-RIB
    is expected to store the effective AS-Path in the
    as-path leaf regardless of being 4-octet or 2-octet.";
  reference
    "RFC 6793 - BGP Support for Four-octet AS Number Space";
  list segment {
    config false;
    uses bgp-as-path-attr;
    description
      "List of AS PATH segments";
  }
}
}

grouping attr-set {
  description
    "A grouping for all path attributes.";

```

```

list attr-set {
  key "index";
  description
    "List of path attributes that may be in use by multiple
    routes in the table";
  leaf index {
    type uint64;
    description
      "System generated index for each attribute set. The
      index is used to reference an attribute set from a
      specific path. Multiple paths may reference the same
      attribute set.";
  }
  uses attr-set-attributes;
}
}

grouping attr-sets {
  description
    "A grouping for all sets of path attributes.";

  container attr-sets {
    description
      "Enclosing container for the list of path attribute sets";
    uses attr-set;
  }
}

grouping rib {
  description
    "Grouping for rib.";
  container rib {
    config false;
    uses attr-sets;
    container communities {
      description
        "Enclosing container for the list of community attribute
        sets.";
      list community {
        key "index";
        config false;
        description
          "List of path attributes that may be in use by multiple
          routes in the table.";
        leaf index {
          type uint64;
          description
            "System generated index for each attribute set. The

```

```

        index is used to reference an attribute set from a
        specific path. Multiple paths may reference the same
        attribute set.";
    }
    uses bgp-community-attr-state;
}
}
container ext-communities {
    description
        "Enclosing container for the list of extended community
        attribute sets.";
    list ext-community {
        key "index";
        config false;
        description
            "List of path attributes that may be in use by multiple
            routes in the table.";
        leaf index {
            type uint64;
            description
                "System generated index for each attribute set. The
                index is used to reference an attribute set from a
                specific path. Multiple paths may reference the same
                attribute set.";
        }
        uses ext-community-attributes;
    }
}
container large-communities {
    description
        "Enclosing container for the list of large community
        attribute sets.";
    list large-community {
        key "index";
        config false;
        description
            "List of path attributes that may be in use by multiple
            routes in the table.";
        leaf index {
            type uint64;
            description
                "System generated index for each attribute set. The
                index is used to reference an attribute set from a
                specific path. Multiple paths may reference the same
                attribute set.";
        }
        uses large-community-attributes;
    }
}
}

```

```

container afi-safis {
    config false;
    description
        "Enclosing container for address family list.";
    list afi-safi {
        key "name";
        description
            "List of afi-safi types.";
        leaf name {
            type identityref {
                base bt:afi-safi-type;
            }
            description
                "AFI,SAFI name.";
        }
        container ipv4-unicast {
            when "../name = 'bt:ipv4-unicast'" {
                description
                    "Include this container for IPv4 unicast RIB.";
            }
            description
                "Routing tables for IPv4 unicast -- active when the
                afi-safi name is ipv4-unicast.";
        }
        container loc-rib {
            config false;
            description
                "Container for the IPv4 BGP LOC-RIB data.";
            container routes {
                description
                    "Enclosing container for list of routes in the
                    routing table.";
                list route {
                    key "prefix origin path-id";
                    description
                        "List of routes in the table, keyed by the route
                        prefix, the route origin, and path-id. The route
                        origin can be either the neighbor address from
                        which the route was learned, or the source
                        protocol that injected the route. The path-id
                        distinguishes routes for the same prefix
                        received from a neighbor (e.g., if add-paths is
                        enabled).";
                    leaf prefix {
                        type inet:ipv4-prefix;
                        description
                            "The IPv4 prefix corresponding to the route.";
                    }
                }
            }
        }
    }
}

```

```

        uses bgp-loc-rib-common-keys;
        uses bgp-loc-rib-common-attr-refs;
        uses bgp-common-route-annotations-state;
        uses bgp-unknown-attr-top;
        uses rib-ext-route-annotations;
    }
}
}

container neighbors {
    config false;
    description
        "Enclosing container for neighbor list.";
    list neighbor {
        key "neighbor-address";
        description
            "List of neighbors (peers) of the local BGP
            speaker.";
        leaf neighbor-address {
            type inet:ip-address;
            description
                "IP address of the BGP neighbor or peer.";
        }
    }
    container adj-rib-in-pre {
        description
            "Per-neighbor table containing the NLRI updates
            received from the neighbor before any local
            input policy rules or filters have been applied.
            This can be considered the 'raw' updates from
            the neighbor.";
        uses ipv4-adj-rib-common;
        uses clear-routes {
            description
                "Clears the adj-rib-in state for the containing
                neighbor. Subsequently, implementations might
                issue a 'route refresh' if 'route refresh' has
                been negotiated, or reset the session. ";
        }
    }
    container adj-rib-in-post {
        description
            "Per-neighbor table containing the paths received
            from the neighbor that are eligible for
            best-path selection after local input policy
            rules have been applied.";
        uses ipv4-adj-rib-in-post;
        uses clear-routes {
            description
                "Clears the adj-rib-in state for the containing

```

```

        neighbor. Subsequently, implementations might
        issue a 'route refresh' if 'route refresh' has
        been negotiated, or reset the session. ";
    }
}
container adj-rib-out-pre {
    description
        "Per-neighbor table containing paths eligible for
        sending (advertising) to the neighbor before
        output policy rules have been applied.";
    uses ipv4-adj-rib-common;
    uses clear-routes {
        description
            "Clears the adj-rib-out state for the
            containing neighbor. Subsequently, neighbors
            will announce BGP updates to resynchronize
            these routes.";
    }
}
container adj-rib-out-post {
    description
        "Per-neighbor table containing paths eligible for
        sending (advertising) to the neighbor after
        output policy rules have been applied.";
    uses ipv4-adj-rib-common;
    uses clear-routes {
        description
            "Clears the adj-rib-out state for the
            containing neighbor. Subsequently, neighbors
            will announce BGP updates to resynchronize
            these routes.";
    }
}
}
}
}

container ipv6-unicast {
    when "../name = 'bt:ipv6-unicast'" {
        description
            "Include this container for IPv6 unicast RIB.";
    }
    description
        "Routing tables for IPv6 unicast -- active when the
        afi-safi name is ipv6-unicast.";

    container loc-rib {
        config false;
        description

```

```

    "Container for the IPv6 BGP LOC-RIB data.";
container routes {
    description
        "Enclosing container for list of routes in the
        routing table.";
    list route {
        key "prefix origin path-id";
        description
            "List of routes in the table, keyed by the route
            prefix, the route origin, and path-id. The route
            origin can be either the neighbor address from
            which the route was learned, or the source
            protocol that injected the route. The path-id
            distinguishes routes for the same prefix
            received from a neighbor (e.g., if add-paths is
            enabled).";
        leaf prefix {
            type inet:ipv6-prefix;
            description
                "The IPv6 prefix corresponding to the route.";
        }
        uses bgp-loc-rib-common-keys;
        uses bgp-loc-rib-common-attr-refs;
        uses bgp-common-route-annotations-state;
        uses bgp-unknown-attr-top;
        uses rib-ext-route-annotations;
    }
}

container neighbors {
    config false;
    description
        "Enclosing container for neighbor list.";
    list neighbor {
        key "neighbor-address";
        description
            "List of neighbors (peers) of the local BGP
            speaker.";
        leaf neighbor-address {
            type inet:ip-address;
            description
                "IP address of the BGP neighbor or peer.";
        }
    }
    container adj-rib-in-pre {
        description
            "Per-neighbor table containing the NLRI updates
            received from the neighbor before any local
            input policy rules or filters have been applied.

```



```

        This can be considered the 'raw' updates from
        the neighbor.";
    uses ipv6-adj-rib-common;
    uses clear-routes {
        description
            "Clears the adj-rib-in state for the containing
            neighbor. Subsequently, implementations might
            issue a 'route refresh' if 'route refresh' has
            been negotiated, or reset the session. ";
    }
}
container adj-rib-in-post {
    description
        "Per-neighbor table containing the paths received
        from the neighbor that are eligible for
        best-path selection after local input policy
        rules have been applied.";
    uses ipv6-adj-rib-in-post;
    uses clear-routes {
        description
            "Clears the adj-rib-in state for the containing
            neighbor. Subsequently, implementations might
            issue a 'route refresh' if 'route refresh' has
            been negotiated, or reset the session. ";
    }
}
container adj-rib-out-pre {
    description
        "Per-neighbor table containing paths eligible for
        sending (advertising) to the neighbor before
        output policy rules have been applied.";
    uses ipv6-adj-rib-common;
    uses clear-routes {
        description
            "Clears the adj-rib-out state for the
            containing neighbor. Subsequently, neighbors
            will announce BGP updates to resynchronize
            these routes.";
    }
}
container adj-rib-out-post {
    description
        "Per-neighbor table containing paths eligible for
        sending (advertising) to the neighbor after
        output policy rules have been applied.";
    uses ipv6-adj-rib-common;
    uses clear-routes {
        description
            "Clears the adj-rib-out state for the

```

containing neighbor. Subsequently, neighbors
will announce BGP updates to resynchronize
these routes.";

```
    }  
  }  
}  
}  
}  
}  
}  
}  
}  
description  
  "Top level container for BGP RIB."  
}  
}  
}
```

<CODE ENDS>

7.4.2. ietf-bgp-rib-types submodule

```
<CODE BEGINS> file "ietf-bgp-rib-types@2022-10-13.yang"
```

```
submodule ietf-bgp-rib-types {  
  yang-version 1.1;  
  belongs-to ietf-bgp {  
    prefix br;  
  }  
}
```

```
organization
```

```
  "IETF IDR Working Group";
```

```
contact
```

```
  "WG Web:  <http://tools.ietf.org/wg/idr>
```

```
  WG List:  <idr@ietf.org>
```

```
  Authors: Mahesh Jethanandani (mjethanandani at gmail.com),  
           Keyur Patel (keyur at arrcus.com),  
           Susan Hares (shares at ndzh.com),  
           Jeffrey Haas (jhaas at juniper.net).";
```

```
description
```

```
  "Defines identity and type definitions associated with  
  the BGP RIB modules.
```

```
  Copyright (c) 2021 IETF Trust and the persons identified as  
  authors of the code. All rights reserved.
```

```
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  forth in Section 4.c of the IETF Trust's Legal Provisions  
  Relating to IETF Documents  
  (https://trustee.ietf.org/license-info).
```

```
  This version of this YANG module is part of RFC XXXX  
  (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself  
  for full legal notices.
```

```
  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 (RFC 2119) (RFC 8174) when, and only when,  
  they appear in all capitals, as shown here.";
```

```
revision 2022-10-13 {
```

```
  description
```

```
    "Initial Version";
```

```
  reference
```

```
    "RFC XXXX, BGP Model for Service Provider Network.";
```

```
}
```

```

identity ineligible-route-reason {
    description
        "Base identity for reason code for routes that are rejected as
        ineligible. Some derived entities are based on BMP v3.";
    reference
        "RFC 7854: BGP Monitoring Protocol.";
}

identity ineligible-cluster-loop {
    base ineligible-route-reason;
    description
        "Route was ineligible due to CLUSTER_LIST loop";
}

identity ineligible-as-loop {
    base ineligible-route-reason;
    description
        "Route was ineligible due to AS_PATH loop";
}

identity ineligible-originator {
    base ineligible-route-reason;
    description
        "Route was ineligible due to ORIGINATOR_ID. For example, update
        has local router as originator";
}

identity ineligible-confed {
    base ineligible-route-reason;
    description
        "Route was ineligible due to a loop in the AS_CONFED_SEQUENCE
        or AS_CONFED_SET attributes";
}

identity bgp-not-selected-bestpath {
    description
        "Base identity for indicating reason a route was was not
        selected by BGP route selection algorithm";
    reference
        "RFC 4271 - Section 9.1";
}

identity local-pref-lower {
    base bgp-not-selected-bestpath;
    description
        "Route has a lower localpref attribute than current best path";
    reference
        "RFC 4271 - Section 9.1.2";
}

```

```

identity as-path-longer {
    base bgp-not-selected-bestpath;
    description
        "Route has a longer AS path attribute than current best path";
    reference
        "RFC 4271 - Section 9.1.2.2 (a)";
}

identity origin-type-higher {
    base bgp-not-selected-bestpath;
    description
        "Route has a higher origin type, i.e., IGP origin is preferred
        over EGP or incomplete";
    reference
        "RFC 4271 - Section 9.1.2.2 (b)";
}

identity med-higher {
    base bgp-not-selected-bestpath;
    description
        "Route has a higher MED, or metric, attribute than the current
        best path";
    reference
        "RFC 4271 - Section 9.1.2.2 (c)";
}

identity prefer-external {
    base bgp-not-selected-bestpath;
    description
        "Route source is via IBGP, rather than EGP.";
    reference
        "RFC 4271 - Section 9.1.2.2 (d)";
}

identity nexthop-cost-higher {
    base bgp-not-selected-bestpath;
    description
        "Route has a higher interior cost to the next hop.";
    reference
        "RFC 4271 - Section 9.1.2.2 (e)";
}

identity higher-router-id {
    base bgp-not-selected-bestpath;
    description
        "Route was sent by a peer with a higher BGP Identifier value.";
    reference
        "RFC 4271 - Section 9.1.2.2 (f)";
}

```

```

}

identity higher-peer-address {
    base bgp-not-selected-bestpath;
    description
        "Route was sent by a peer with a higher IP address";
    reference
        "RFC 4271 - Section 9.1.2.2 (g)";
}

identity bgp-not-selected-policy {
    description
        "Base identity for reason code for routes that are rejected
        due to policy";
}

identity rejected-import-policy {
    base bgp-not-selected-policy;
    description
        "Route was rejected after applying import policies.";
}
}

```

<CODE ENDS>

7.4.3. ietf-bgp-rib-attributes submodule

<CODE BEGINS> file "ietf-bgp-rib-attributes@2022-10-13.yang"

```
submodule ietf-bgp-rib-attributes {
  yang-version 1.1;
  belongs-to ietf-bgp {
    prefix br;
  }

  // import some basic types

  import iana-bgp-types {
    prefix bt;
  }
  import ietf-inet-types {
    prefix inet;
  }
  include ietf-bgp-rib-types;

  // meta

  organization
    "IETF IDR Working Group";
  contact
    "WG Web:  <http://tools.ietf.org/wg/idr>
    WG List:  <idr@ietf.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
             Keyur Patel (keyur at arccus.com),
             Susan Hares (shares at ndzh.com),
             Jeffrey Haas (jhaas at juniper.net).";

  description
    "This submodule contains common data definitions for BGP
    attributes for use in BGP RIB tables.

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    authors of the code. All rights reserved.

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    Relating to IETF Documents
    (https://trustee.ietf.org/license-info).

    This version of this YANG module is part of RFC XXXX
    (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
    for full legal notices.

    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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
    "Initial version";
  reference
    "RFC XXXX: BGP YANG Model for Service Provider Network";
}

grouping bgp-as-path-attr {
  description
    "Data for representing BGP AS-PATH attribute";

  leaf type {
    type identityref {
      base bt:as-path-segment-type;
    }
    description
      "The type of AS-PATH segment";
  }
  leaf-list member {
    type inet:as-number;
    description
      "List of the AS numbers in the AS-PATH segment";
  }
}

grouping bgp-community-attr-state {
  description
    "Common definition of BGP community attributes";
  leaf-list community {
    type union {
      type bt:as-path-segment-type;
      type bt:as-path-segment-type;
    }
    description
      "List of standard or well-known BGP community
        attributes.";
  }
}

grouping bgp-unknown-attr-top {
  description
    "Unknown path attributes that are not expected to be shared
      across route entries, common to LOC-RIB and Adj-RIB";
  container unknown-attributes {
```

```

description
    "Unknown path attributes that were received in the UPDATE
    message which contained the prefix.";

list unknown-attribute {
    key "attr-type";
    description
        "This list contains received attributes that are
        unrecognized or unsupported by the local router. The list
        may be empty.";

    leaf optional {
        type boolean;
        description
            "Defines whether the attribute is optional (if
            set to true) or well-known (if set to false).
            Set in the high-order bit of the BGP attribute
            flags octet.";
        reference
            "RFC 4271 - A Border Gateway Protocol 4 (BGP-4)";
    }

    leaf transitive {
        type boolean;
        description
            "Defines whether an optional attribute is transitive
            (if set to true) or non-transitive (if set to false).
            For well-known attributes, the transitive flag must be
            set to true. Set in the second high-order bit of the BGP
            attribute flags octet.";
        reference
            "RFC 4271 - A Border Gateway Protocol 4 (BGP-4)";
    }

    leaf partial {
        type boolean;
        description
            "Defines whether the information contained in the
            optional transitive attribute is partial (if set to
            true) or complete (if set to false). For well-known
            attributes and for optional non-transitive attributes,
            the partial flag must be set to false. Set in the third
            high-order bit of the BGP attribute flags octet.";
        reference
            "RFC 4271 - A Border Gateway Protocol 4 (BGP-4)";
    }

    leaf extended {
        type boolean;
    }

```

```

        description
            "Defines whether the attribute length is one octet
            (if set to false) or two octets (if set to true). Set in
            the fourth high-order bit of the BGP attribute flags
            octet.";
        reference
            "RFC 4271 - A Border Gateway Protocol 4 (BGP-4)";
    }

    leaf attr-type {
        type uint8;
        description
            "1-octet value encoding the attribute type code";
        reference
            "RFC 4271 - A Border Gateway Protocol 4 (BGP-4)";
    }

    leaf attr-len {
        type uint16;
        description
            "One or two octet attribute length field indicating the
            length of the attribute data in octets. If the Extended
            Length attribute flag is set, the length field is 2
            octets, otherwise it is 1 octet";
        reference
            "RFC 4271 - A Border Gateway Protocol 4 (BGP-4)";
    }

    leaf attr-value {
        type binary {
            length "0..65535";
        }
        description
            "Raw attribute value, not including the attribute
            flags, type, or length. The maximum length
            of the attribute value data is 2^16-1 per the max value
            of the attr-len field (2 octets).";
        reference
            "RFC 4271 - A Border Gateway Protocol 4 (BGP-4)";
    }
}

}

}

grouping bgp-adj-rib-attr-state {
    description
        "Path attributes that are not expected to be shared across
        route entries, specific to Adj-RIB";
    leaf path-id {

```

```

    type uint32;
    description
        "When the BGP speaker supports advertisement of multiple
        paths for a prefix, the path identifier is used to
        uniquely identify a route based on the combination of the
        prefix and path id. In the Adj-RIB-In, the path-id value is
        the value received in the update message. In the Loc-RIB,
        if used, it should represent a locally generated path-id
        value for the corresponding route. In Adj-RIB-Out, it
        should be the value sent to a neighbor when add-paths is
        used, i.e., the capability has been negotiated.";
    reference
        "RFC 7911: Advertisement of Multiple Paths in BGP";
}
}

grouping ext-community-attributes {
    description
        "A grouping for all extended community parameters.";

    leaf-list ext-community {
        type bt:bgp-ext-community-type;
        description
            "List of BGP extended community attributes. The received
            extended community may be an explicitly modeled
            type or unknown, represented by an 8-octet value
            formatted according to RFC 4360.";
        reference
            "RFC 4360 - BGP Extended Communities Attribute";
    }

    leaf-list ext-community-raw {
        type string {
            // raw with 8 octets
            pattern 'raw:([0-9A-F][0-9A-F:]){7}[0-9A-F][0-9A-F]';
        }
        description
            "ext-community type in raw format only.";
    }
}

grouping large-community-attributes {
    description
        "A grouping for all large community parameters.";

    leaf-list large-community {
        type bt:bgp-large-community-type;
        description
            "List of BGP large community attributes.";
    }
}

```

```
reference
  "RFC 8092: BGP Large Communities Attribute.";
}
}
}

<CODE ENDS>
```

7.4.4. ietf-bgp-rib-tables submodule

<CODE BEGINS> file "ietf-bgp-rib-tables@2022-10-13.yang"

```
submodule ietf-bgp-rib-tables {
  yang-version 1.1;
  belongs-to ietf-bgp {
    prefix br;
  }

  // import some basic types

  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991: Common YANG Data Types.";
  }
  import ietf-yang-types {
    prefix yang;
    reference
      "RFC 6991: Common YANG Data Types.";
  }
  import ietf-routing {
    prefix rt;
    reference
      "RFC 8022: A YANG Data Model for Routing Management.";
  }
  import iana-bgp-types {
    prefix bt;
    reference
      "RFC XXXX: BGP YANG Model for Service Provider Network.";
  }
  include ietf-bgp-rib-attributes;

  organization
    "IETF IDR Working Group";
  contact
    "WG Web:  <http://tools.ietf.org/wg/idr>
    WG List:  <idr@ietf.org>

    Authors: Mahesh Jethanandani (mjethanandani at gmail.com),
             Keyur Patel (keyur at arrcus.com),
             Susan Hares (shares at ndzh.com),
             Jeffrey Haas (jhaas at juniper.net).";

  description
    "This submodule contains structural data definitions for
    BGP routing tables.

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    authors of the code. All rights reserved."
```


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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 (RFC 2119) (RFC 8174) when, and only when, they appear in all capitals, as shown here.";

```
revision 2022-10-13 {
  description
    "Initial Version";
  reference
    "RFC XXXX, BGP YANG Model for Service Provider Network.";
}

grouping bgp-common-route-annotations-state {
  description
    "Data definitions for flags and other information attached
    to routes in both LOC-RIB and Adj-RIB";
  leaf last-modified {
    type yang:timeticks;
    description
      "Timestamp when this path was last modified.

      The value is the timestamp in seconds relative to
      the Unix Epoch (Jan 1, 1970 00:00:00 UTC).";
  }
  leaf eligible-route {
    type boolean;
    description
      "Indicates that the route is eligible for selection for the
      best route in the Loc-Rib in BGP's Decision Process.";
    reference
      "RFC 4271, Section 9.1.";
  }
  leaf ineligible-reason {
    type identityref {
      base ineligible-route-reason;
    }
    description
```

```

        "If the route is ineligible for selection for the best route
        in the Loc-Rib in BGP's Decision process, this indicates the
        reason.";
    reference
        "RFC 4271, Section 9.1.";
}
}

grouping bgp-adj-rib-in-post-route-annotations-state {
    description
        "Data definitions for information attached to routes in the
        Adj-RIB-in post-policy table";
    leaf best-path {
        type boolean;
        description
            "Current path was selected as the best path. Best path
            should indicate that the route is present in BGP LOC-RIB.";
    }
}

grouping rib-ext-route-annotations {
    description
        "Extended annotations for routes in the routing tables";
    leaf reject-reason {
        type union {
            type identityref {
                base bgp-not-selected-bestpath;
            }
            type identityref {
                base bgp-not-selected-policy;
            }
        }
        description
            "Indicates the reason the route is not used, either due to
            policy filtering or bestpath selection";
    }
}

grouping bgp-adj-rib-common-attr-refs {
    description
        "Definitions of common references to attribute sets for
        multiple AFI-SAFIs for Adj-RIB tables.";
    leaf attr-index {
        type leafref {
            path "../.../.../.../.../.../attr-sets/"
                + "attr-set/index";
        }
        description
            "Reference to the common attribute group for the

```

```

        route.";
    }
    leaf community-index {
        type leafref {
            path "../../../../../communities/community/"
                + "index";
        }
        description
            "Reference to the community attribute for the route.";
    }
    leaf ext-community-index {
        type leafref {
            path "../../../../../ext-communities/"
                + "ext-community/index";
        }
        description
            "Reference to the extended community attribute for the
            route.";
    }
}

grouping bgp-loc-rib-common-attr-refs {
    description
        "Definitions of common references to attribute sets for
        multiple AFI-SAFIs for LOC-RIB tables.";
    leaf attr-index {
        type leafref {
            path "../../../../attr-sets/attr-set/"
                + "index";
        }
        description
            "Reference to the common attribute group for the
            route.";
    }
    leaf community-index {
        type leafref {
            path "../../../../../communities/community/"
                + "index";
        }
        description
            "Reference to the community attribute for the route.";
    }
    leaf ext-community-index {
        type leafref {
            path "../../../../../ext-communities/"
                + "ext-community/index";
        }
        description
            "Reference to the extended community attribute for the

```

```

        route.";
    }
}

grouping bgp-loc-rib-common-keys {
    description
        "Common references used in keys for IPv4 and IPv6
        LOC-RIB entries.";
    leaf origin {
        type union {
            type inet:ip-address;
            type identityref {
                base rt:routing-protocol;
            }
        }
        description
            "Indicates the origin of the route.  If the route is learned
            from a neighbor, this value is the neighbor address.  If
            the route was injected or redistributed from another
            protocol, the origin indicates the source protocol for the
            route.";
    }
    leaf path-id {
        type uint32;
        description
            "If the route is learned from a neighbor, the path-id
            corresponds to the path-id for the route in the
            corresponding adj-rib-in-post table.  If the route is
            injected from another protocol, or the neighbor does not
            support BGP add-paths, the path-id should be set
            to zero, also the default value.

            However, YANG does not allow default values to be set
            for parameters that form the key, so a default value
            cannot be set here.";
    }
}

grouping clear-routes {
    description
        "Action to clear BGP routes.";
    container clear-routes {
        if-feature "bt:clear-routes";
        action clear {
            input {
                leaf clear-at {
                    type yang:date-and-time;
                    description
                        "The time, in the future when the clear operation will

```

```

        be initiated.";
    }
}
output {
    leaf clear-finished-at {
        type yang:date-and-time;
        description
            "The time when the clear operation finished.";
    }
}
}
description
    "Action commands to clear routes governed by a if-feature.";
}
}

```

```

grouping ipv4-adj-rib-common {
    description
        "Common structural grouping for each IPv4 adj-RIB table.";
    container routes {
        config false;
        description
            "Enclosing container for list of routes in the routing
            table.";
        list route {
            key "prefix path-id";
            description
                "List of routes in the table, keyed by a combination of
                the route prefix and path-id to distinguish multiple
                routes received from a neighbor for the same prefix,
                e.g., when BGP add-paths is enabled.";
            leaf prefix {
                type inet:ipv4-prefix;
                description
                    "Prefix for the route.";
            }
            uses bgp-adj-rib-attr-state;
            uses bgp-adj-rib-common-attr-refs;
            uses bgp-common-route-annotations-state;
            uses bgp-unknown-attr-top;
            uses rib-ext-route-annotations;
        }
    }
}
}

```

```

grouping ipv4-adj-rib-in-post {
    description
        "Common structural grouping for the IPv4 adj-rib-in
        post-policy table.";
}

```

```

container routes {
  config false;
  description
    "Enclosing container for list of routes in the routing
      table.";
  list route {
    key "prefix path-id";
    description
      "List of routes in the table, keyed by a combination of
        the route prefix and path-id to distinguish multiple
        routes received from a neighbor for the same prefix,
        e.g., when BGP add-paths is enabled.";
    leaf prefix {
      type inet:ipv4-prefix;
      description
        "Prefix for the route.";
    }
    uses bgp-adj-rib-attr-state;
    uses bgp-adj-rib-common-attr-refs;
    uses bgp-common-route-annotations-state;
    uses bgp-adj-rib-in-post-route-annotations-state;
    uses bgp-unknown-attr-top;
    uses rib-ext-route-annotations;
  }
}

```

```

grouping ipv6-adj-rib-common {
  description
    "Common structural grouping for each IPv6 adj-RIB table.";
  container routes {
    config false;
    description
      "Enclosing container for list of routes in the routing
        table.";
    list route {
      key "prefix path-id";
      description
        "List of routes in the table.";
      leaf prefix {
        type inet:ipv6-prefix;
        description
          "Prefix for the route.";
      }
      uses bgp-adj-rib-attr-state;
      uses bgp-adj-rib-common-attr-refs;
      uses bgp-common-route-annotations-state;
      uses bgp-unknown-attr-top;
      uses rib-ext-route-annotations;
    }
  }
}

```

```

    }
  }
}

grouping ipv6-adj-rib-in-post {
  description
    "Common structural grouping for the IPv6 adj-rib-in
    post-policy table.";
  container routes {
    config false;
    description
      "Enclosing container for list of routes in the routing
      table.";
    list route {
      key "prefix path-id";
      description
        "List of routes in the table.";
      leaf prefix {
        type inet:ipv6-prefix;
        description
          "Prefix for the route.";
      }
      uses bgp-adj-rib-attr-state;
      uses bgp-adj-rib-common-attr-refs;
      uses bgp-common-route-annotations-state;
      uses bgp-adj-rib-in-post-route-annotations-state;
      uses bgp-unknown-attr-top;
      uses rib-ext-route-annotations;
    }
  }
}
}

```

<CODE ENDS>

8. Contributors

Previous versions of this document saw contributions from Anees Shaikh, Rob Shakir, Kevin D'Souza, Alexander Clemm, Aleksandr Zhadkin, and Xyfeng Liu.

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Lindem, Ina Minei, Carl Moberg, Ashok Narayanan, Einar Nilsen-Nygaard, Adam Simpson, Puneet Sood, Jason Sterne, Jeff Tantsura, Jim Uttaro, and Gunter Vandevelde.

Credit is also due to authors of the OpenConfig, whose model was relied upon to come up with this model.

Special thanks to Robert Wilton who helped convert the YANG models to a NMDA compatible model, and to Derek Yeung in helping out with Extended Communities support in the model.

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Appendix A. Examples

This section tries to show some examples in how the model can be used.

A.1. Creating BGP Instance

This example shows how to enable BGP for a IPv4 unicast address family.

[note: '\\' line wrapping for formatting only]

```
<?xml version="1.0" encoding="UTF-8"?>
<routing
  xmlns="urn:ietf:params:xml:ns:yang:ietf-routing">
  <control-plane-protocols>
    <control-plane-protocol>
      <type
        xmlns:bgp="urn:ietf:params:xml:ns:yang:ietf-bgp">bgp:bgp</\
type>
      <name>BGP</name>
      <bgp
        xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp">
        <global>
          <as>64496</as>
          <afi-safis>
            <afi-safi>
              <name
                xmlns:bt=
                  "urn:ietf:params:xml:ns:yang:iana-bgp-types">bt:ip\
v4-unicast</name>
              </afi-safi>
            </afi-safis>
          </global>
        </bgp>
      </control-plane-protocol>
    </control-plane-protocols>
  </routing>
```

A.2. Neighbor Address Family Configuration

This example shows how to configure a BGP neighbor, where the remote address is 192.0.2.1, the remote AS number is 64497, and the address family of the neighbor is IPv4 unicast. The neighbor is configured for route flap prevention and it set up for standard and large communities. In addition, BFD is configured at a neighbor level with a local multiplier of 2, a desired minimum transmit interval, and a required minimum receive interval of 3.3 ms.

[note: '\\' line wrapping for formatting only]

<!--

 This example shows a neighbor configuration with damping.

-->

<?xml version="1.0" encoding="UTF-8"?>

<routing

 xmlns="urn:ietf:params:xml:ns:yang:ietf-routing"

 xmlns:bt="urn:ietf:params:xml:ns:yang:iana-bgp-types">

 <control-plane-protocols>

 <control-plane-protocol>

 <type

 xmlns:bgp="urn:ietf:params:xml:ns:yang:ietf-bgp">bgp:bgp</\

type>

 <name>name:BGP</name>

 <bgp

 xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp">

 <global>

 <as>64496</as>

 <afi-safis>

 <afi-safi>

 <name>bt:ipv4-unicast</name>

 </afi-safi>

 </afi-safis>

 </global>

 <neighbors>

 <neighbor>

 <remote-address>192.0.2.1</remote-address>

 <peer-as>64497</peer-as>

 <route-flap-damping>

 <enable>true</enable>

 <suppress-above>4.0</suppress-above>

 <reuse-above>3.0</reuse-above>

 <max-flap>15.0</max-flap>

 <reach-decay>100</reach-decay>

 <unreach-decay>500</unreach-decay>

 <keep-history>1000</keep-history>

 </route-flap-damping>

 <send-community>bt:standard</send-community>

 <send-community>bt:large</send-community>

 <description>"Peer Router B"</description>

 <afi-safis>

 <afi-safi>

 <name>bt:ipv4-unicast</name>

 </afi-safi>

 </afi-safis>

 <bfd>

 <enabled>true</enabled>

```
        <local-multiplier>2</local-multiplier>
        <desired-min-tx-interval>3300</desired-min-tx-interval\
>
        <required-min-rx-interval>3300</required-min-rx-interv\
al>
    </bfd>
    <transport>
        <tcp-mss>1400</tcp-mss>
        <mtu-discovery>true</mtu-discovery>
    </transport>
</neighbor>
</neighbors>
</bgp>
</control-plane-protocol>
</control-plane-protocols>
</routing>
```


A.3. IPv6 Neighbor Configuration

This example shows how to configure a BGP peer, where the remote peer has a IPv6 address, uses TCP-AO to secure the session with the peer, and uses non-default timers for hold-time and keepalive.

[note: '\\' line wrapping for formatting only]

```
<?xml version="1.0" encoding="UTF-8"?>
<key-chains
  xmlns="urn:ietf:params:xml:ns:yang:ietf-key-chain">
  <key-chain>
    <name>bgp-key-chain</name>
    <description>"An example of TCP-AO configuration for BGP"</descri\
ption>
    <key>
      <key-id>55</key-id>
      <lifetime>
        <send-lifetime>
          <start-date-time>2017-01-01T00:00:00Z</start-date-time>
          <end-date-time>2017-02-01T00:00:00Z</end-date-time>
        </send-lifetime>
        <accept-lifetime>
          <start-date-time>2016-12-31T23:59:55Z</start-date-time>
          <end-date-time>2017-02-01T00:00:05Z</end-date-time>
        </accept-lifetime>
      </lifetime>
      <crypto-algorithm
        xmlns:tcp=
          "urn:ietf:params:xml:ns:yang:ietf-tcp">tcp:aes-128</crypto-algor
m>
      <key-string>
        <keystring>testvector</keystring>
      </key-string>
      <authentication
        xmlns="urn:ietf:params:xml:ns:yang:ietf-tcp">
        <keychain>bgp-key-chain</keychain>
        <ao>
          <send-id>65</send-id>
          <recv-id>87</recv-id>
        </ao>
      </authentication>
    </key>
    <key>
      <key-id>56</key-id>
      <lifetime>
        <send-lifetime>
          <start-date-time>2017-01-01T00:00:00Z</start-date-time>
          <end-date-time>2017-02-01T00:00:00Z</end-date-time>
        </send-lifetime>
        <accept-lifetime>
          <start-date-time>2016-12-31T23:59:55Z</start-date-time>
          <end-date-time>2017-02-01T00:00:05Z</end-date-time>
        </accept-lifetime>
      </lifetime>
```

```

    <crypto-algorithm
      xmlns:tcp=
        "urn:ietf:params:xml:ns:yang:ietf-tcp">tcp:aes-128</crypto-algor
m>
    <key-string>
      <keystring>testvector</keystring>
    </key-string>
    <authentication
      xmlns="urn:ietf:params:xml:ns:yang:ietf-tcp">
      <keychain>bgp-key-chain</keychain>
      <ao>
        <send-id>65</send-id>
        <recv-id>87</recv-id>
      </ao>
    </authentication>
  </key>
</key-chain>
</key-chains>

<routing
  xmlns="urn:ietf:params:xml:ns:yang:ietf-routing">
  <control-plane-protocols>
    <control-plane-protocol>
      <type
        xmlns:bgp="urn:ietf:params:xml:ns:yang:ietf-bgp">bgp:bgp</\
type>
      <name>name:BGP</name>
      <bgp
        xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp">
        <global>
          <as>64496</as>
          <afi-safis>
            <afi-safi>
              <name
                xmlns:bt=
                  "urn:ietf:params:xml:ns:yang:iana-bgp-types">bt:ip\
v6-unicast</name>
              </afi-safi>
            </afi-safis>
          </global>
          <neighbors>
            <neighbor>
              <remote-address>2001:db8::</remote-address>
              <enabled>true</enabled>
              <secure-session-enable>true</secure-session-enable>
              <secure-session>
                <ao-keychain>bgp-key-chain</ao-keychain>
              </secure-session>
              <peer-as>64497</peer-as>
            </neighbor>
          </neighbors>
        </bgp>
      </type>
    </control-plane-protocol>
  </control-plane-protocols>
</routing>

```

```
<description>"Peer Router B"</description>
<timers>
  <hold-time>120</hold-time>
  <keepalive>70</keepalive>
</timers>
<afi-safis>
  <afi-safi>
    <name
      xmlns:bt=
        "urn:ietf:params:xml:ns:yang:iana-bgp-types">bt:\
ipv6-unicast</name>
    </afi-safi>
  </afi-safis>
</neighbor>
</neighbors>
</bgp>
</control-plane-protocol>
</control-plane-protocols>
</routing>
```

A.4. VRF Configuration

This example shows how BGP can be configured for two VRFs, red and blue. In this case, the two network instances share a common AS, and distinguish between the instances using the router id.

[note: '\\' line wrapping for formatting only]

```
<?xml version="1.0" encoding="UTF-8"?>
<network-instances
  xmlns="urn:ietf:params:xml:ns:yang:ietf-network-instance">
  <network-instance>
    <name>vrf-red</name>
    <vrf-root>
      <routing
        xmlns="urn:ietf:params:xml:ns:yang:ietf-routing">
        <router-id>192.0.2.1</router-id>
        <control-plane-protocols>
          <control-plane-protocol>
            <type
              xmlns:bgp=
                "urn:ietf:params:xml:ns:yang:ietf-bgp">bgp:bgp</type\
>
              <name>BGP</name>
              <bgp
                xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp">
                <global>
                  <as>64496</as>
                  <afi-safis>
                    <afi-safi>
                      <name
                        xmlns:bt=
                          "urn:ietf:params:xml:ns:yang:iana-bgp-types"\
>bt:ipv4-unicast</name>
                      </afi-safi>
                    </afi-safis>
                  </global>
                </bgp>
              </control-plane-protocol>
            </control-plane-protocols>
          </routing>
        </vrf-root>
      </network-instance>
      <network-instance>
        <name>vrf-blue</name>
        <vrf-root>
          <routing
            xmlns="urn:ietf:params:xml:ns:yang:ietf-routing">
            <router-id>192.0.2.2</router-id>
            <control-plane-protocols>
              <control-plane-protocol>
                <type
                  xmlns:bgp=
                    "urn:ietf:params:xml:ns:yang:ietf-bgp">bgp:bgp</type\
>
```

```

    <name>BGP</name>
    <bgp
      xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp">
      <global>
        <as>64496</as>
        <afi-safis>
          <afi-safi>
            <name
              xmlns:bt=
                "urn:ietf:params:xml:ns:yang:iana-bgp-types"\
>bt:ipv4-unicast</name>
              </afi-safi>
            </afi-safis>
          </global>
        </bgp>
      </control-plane-protocol>
    </control-plane-protocols>
  </routing>
</vrf-root>
</network-instance>
</network-instances>

```

A.5. BGP Policy - Match Prefix and Set Community

Routing policy using community value involves configuring rules to match community values in the inbound or outbound direction. In this example, which is heavily borrowed from the example on the Cisco community page, we look at "match community exact" match, which happens only when BGP updates have the same community values as specified in the community list.

The topology in this example consists of three routers, R1, R2, and R3, configured with AS value of 1, 2 and 3 respectively. R1 advertises 5 prefixes to R2 and R3, as shown below.

*1.1.1.1/32 and 2.2.2.2/32 with community 11:11

*3.3.3.3/32 and 4.4.4.4/32 with community 11:11 and 22:22

*5.5.5.5/32 with community 33:33

Route Policy TO_R2 defines the policy that R1 uses in route updates towards R2. It consists of three statements, statement 10 that has a exact match rule for the prefix list L0andL1, and a set-community action of add for 11:11. The second statement, statement 20, consists of an exact match rule for prefix list L2andL3, with a set community action of remove for 11:11 22:22. The final statement, statement 30, consists of an exact match rule for prefix list L4, with a set community action of replace for 33:33.

[note: '\\' line wrapping for formatting only]

```
<?xml version="1.0" encoding="UTF-8"?>
<routing-policy
  xmlns="urn:ietf:params:xml:ns:yang:ietf-routing-policy">
  <defined-sets>
    <prefix-sets>
      <prefix-set>
        <name>L0andL1</name>
        <mode>ipv4</mode>
        <prefixes>
          <prefix-list>
            <ip-prefix>1.1.1.1/32</ip-prefix>
            <mask-length-lower>32</mask-length-lower>
            <mask-length-upper>32</mask-length-upper>
          </prefix-list>
          <prefix-list>
            <ip-prefix>2.2.2.2/32</ip-prefix>
            <mask-length-lower>32</mask-length-lower>
            <mask-length-upper>32</mask-length-upper>
          </prefix-list>
        </prefixes>
      </prefix-set>
      <prefix-set>
        <name>L2andL3</name>
        <mode>ipv4</mode>
        <prefixes>
          <prefix-list>
            <ip-prefix>3.3.3.3/32</ip-prefix>
            <mask-length-lower>32</mask-length-lower>
            <mask-length-upper>32</mask-length-upper>
          </prefix-list>
          <prefix-list>
            <ip-prefix>4.4.4.4/32</ip-prefix>
            <mask-length-lower>32</mask-length-lower>
            <mask-length-upper>32</mask-length-upper>
          </prefix-list>
        </prefixes>
      </prefix-set>
      <prefix-set>
        <name>L4</name>
        <mode>ipv4</mode>
        <prefixes>
          <prefix-list>
            <ip-prefix>5.5.5.5/32</ip-prefix>
            <mask-length-lower>32</mask-length-lower>
            <mask-length-upper>32</mask-length-upper>
          </prefix-list>
        </prefixes>
      </prefix-set>
    </prefix-sets>
  </defined-sets>
</routing-policy>
```

```

    </prefix-set>
  </prefix-sets>
</defined-sets>
<policy-definitions>
  <policy-definition>
    <name>T0_R2</name>
    <statements>
      <statement>
        <name>10</name>
        <conditions>
          <match-prefix-set>
            <prefix-set>L0andL1</prefix-set>
          </match-prefix-set>
        </conditions>
        <actions>
          <bgp-actions
            xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp-policy">\

            <set-community>
              <options>add</options>
              <communities>11:11</communities>
            </set-community>
          </bgp-actions>
        </actions>
      </statement>
      <statement>
        <name>20</name>
        <conditions>
          <match-prefix-set>
            <prefix-set>L2andL3</prefix-set>
          </match-prefix-set>
        </conditions>
        <actions>
          <bgp-actions
            xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp-policy">\

            <set-community>
              <options>remove</options>
              <communities>11:11</communities>
              <communities>22:22</communities>
            </set-community>
          </bgp-actions>
        </actions>
      </statement>
      <statement>
        <name>30</name>
        <conditions>
          <match-prefix-set>
            <prefix-set>L4</prefix-set>

```

```

        </match-prefix-set>
    </conditions>
    <actions>
        <bgp-actions
            xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp-policy">\

            <set-community>
                <options>replace</options>
                <communities>33:33</communities>
            </set-community>
        </bgp-actions>
    </actions>
</statement>
</statements>
</policy-definition>
</policy-definitions>
</routing-policy>

<routing
    xmlns="urn:ietf:params:xml:ns:yang:ietf-routing"
    xmlns:bt="urn:ietf:params:xml:ns:yang:iana-bgp-types">
    <control-plane-protocols>
        <control-plane-protocol>
            <type
                xmlns:bgp="urn:ietf:params:xml:ns:yang:ietf-bgp">bgp:bgp</\
type>
            <name>BGP</name>
            <bgp
                xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp">
                <global>
                    <as>1</as>
                    <afi-safis>
                        <afi-safi>
                            <name>bt:ipv4-unicast</name>
                        </afi-safi>
                    </afi-safis>
                </global>
                <neighbors>
                    <neighbor>
                        <remote-address>10.1.1.2</remote-address>
                        <peer-as>2</peer-as>
                        <afi-safis>
                            <afi-safi>
                                <name>bt:ipv4-unicast</name>
                            </afi-safi>
                        </afi-safis>
                        <send-community>bt:standard</send-community>
                        <apply-policy>
                            <export-policy>T0_R2</export-policy>

```

```
        <default-export-policy>accept-route</default-export-po\
licy>
        </apply-policy>
    </neighbor>
</neighbors>
</bgp>
</control-plane-protocol>
</control-plane-protocols>
</routing>
```

A.6. BGP Policy - Match Next-hop and Set Community

In this example, a "next-hop-set" is configured using option "invert" from "match-set-options" to match next-hop not equal to "192.0.2.2" and then set community to 55:55.

[note: '\\' line wrapping for formatting only]

```
<?xml version='1.0' encoding='UTF-8'?>
  <routing-policy xmlns="urn:ietf:params:xml:ns:yang:ietf-routing-po\
  licy">
    <defined-sets>
      <bgp-defined-sets xmlns="urn:ietf:params:xml:ns:yang:ietf-bgp-\
  policy">
        <next-hop-sets>
          <next-hop-set>
            <name>nexthop_not2</name>
            <next-hop>192.0.2.2</next-hop>
          </next-hop-set>
        </next-hop-sets>
      </bgp-defined-sets>
    </defined-sets>
    <policy-definitions>
      <policy-definition>
        <name>nexthop_not2_community</name>
        <statements>
          <statement>
            <name>100</name>
            <conditions>
              <bgp-conditions xmlns="urn:ietf:params:xml:ns:yang:iet\
  f-bgp-policy">
                <match-next-hop-set>
                  <next-hop-set>nexthop_not2</next-hop-set>
                  <match-set-options>invert</match-set-options>
                </match-next-hop-set>
              </bgp-conditions>
            </conditions>
            <actions>
              <bgp-actions xmlns="urn:ietf:params:xml:ns:yang:ietf-b\
  gp-policy">
                <set-community>
                  <options>add</options>
                  <communities>55:55</communities>
                </set-community>
              </bgp-actions>
            </actions>
          </statement>
        </statements>
      </policy-definition>
    </policy-definitions>
  </routing-policy>
```

Appendix B. How to add a new AFI and Augment a Module

This section explains how a new AFI can be defined in a new module and how that module can then be augmented. Assume that the new AFI being defined is called 'foo' which extends the base identity of 'afi-safi-type', and the augmentation is to add a new container for 'foo' under two different XPaths. The example shows how the base identity can be extended to add this new AFI, and then use the augmented containers be used to add 'foo' specific information.

```

module example-newafi-bgp {
  yang-version 1.1;
  namespace "http://example.com/ns/example-newafi-bgp";
  prefix example-newafi-bgp;

  import ietf-inet-types {
    prefix inet;
    reference
      "RFC 6991: Common YANG Data Types.";
  }

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

  import ietf-bgp {
    prefix "bgp";
    reference
      "RFC XXXX: BGP YANG module for Service Provider Network.";
  }

  import iana-bgp-types {
    prefix "bt";
  }

  organization
    "Newafi model group.";

  contact
    "abc@newafi.com";
  description
    "This YANG module defines and uses new AFI.";

  revision 2022-10-13 {
    description
      "Creating new AFI and using in this model";

    reference
      "RFC XXXX: BGP YANG Model for Service Provider Network.";
  }

  identity foo {
    base bt:afi-safi-type;
    description
      "New AFI type foo.";
  }
}

```



```

augment "/rt:routing/rt:control-plane-protocols/" +
    "rt:control-plane-protocol/bgp:bgp/bgp:global/" +
    "bgp:afi-safis/bgp:afi-safi" {
    when "derived-from-or-self(bgp:name, 'foo')" {
        description
            "This augmentation is valid for a AFI/SAFI instance
            of 'foo'";
    }
    container foo {
        description
            "Container to add 'foo' specific AFI/SAFI information.
            First add the common stuff.";
        uses bgp:mp-all-afi-safi-common;
    }
}

augment "/rt:routing/rt:control-plane-protocols/" +
    "rt:control-plane-protocol/bgp:bgp/" +
    "bgp:rib/bgp:afi-safis/bgp:afi-safi" {
    when "derived-from-or-self(bgp:name, 'foo')" {
        description
            "This augmentation is valid for a AFI/SAFI instance
            of 'foo'";
    }
}

container foo {
    description
        "Container to add 'foo' rib specific information.
        First add the common stuff.";
    container loc-rib {
        config false;
        description
            "Container for the 'foo' BGP LOC-RIB data.";
        container routes {
            description
                "Enclosing container for list of routes in the routing
                table.";
            list route {
                key "prefix origin path-id";
                description
                    "List of routes in the table, keyed by the route
                    prefix, the route origin, and path-id. The route
                    origin can be either the neighbor address from which
                    the route was learned, or the source protocol that
                    injected the route. The path-id distinguishes routes
                    for the same prefix received from a neighbor (e.g.,
                    if add-paths is enabled).";
                leaf prefix {
                    type inet:ip-address;
                }
            }
        }
    }
}

```

```

        description
            "The 'foo' prefix corresponding to the route.";
    }
    uses bgp:bgp-loc-rib-common-keys;
    uses bgp:bgp-loc-rib-common-attr-refs;
    uses bgp:bgp-common-route-annotations-state;
    uses bgp:bgp-unknown-attr-top;
    uses bgp:rib-ext-route-annotations;
}
uses bgp:clear-routes;
}
}

container neighbors {
    config false;
    description
        "Enclosing container for neighbor list.";
    list neighbor {
        key "neighbor-address";
        description
            "List of neighbors (peers) of the local BGP speaker.";
        leaf neighbor-address {
            type inet:ip-address;
            description
                "IP address of the BGP neighbor or peer.";
        }
        container adj-rib-in-pre {
            description
                "Per-neighbor table containing the NLRI updates
                received from the neighbor before any local input
                policy rules or filters have been applied. This can
                be considered the 'raw' updates from the neighbor.";
            uses bgp:ipv4-adj-rib-common;
        }
        container adj-rib-in-post {
            description
                "Per-neighbor table containing the paths received from
                the neighbor that are eligible for best-path selection
                after local input policy rules have been applied.";
            uses bgp:ipv4-adj-rib-in-post;
        }
        container adj-rib-out-pre {
            description
                "Per-neighbor table containing paths eligible for
                sending (advertising) to the neighbor before output
                policy rules have been applied.";
            uses bgp:ipv4-adj-rib-common;
        }
        container adj-rib-out-post {

```

```
description
  "Per-neighbor table containing paths eligible for
  sending (advertising) to the neighbor after output
  policy rules have been applied.";
uses bgp:ipv4-adj-rib-common;
}
}
}
}
}
```

Appendix C. How to deviate a module

This example shows how the BGP can be deviated to indicate two nodes that the particular implementation is choosing not to support.

```
module example-newco-bgp {
  yang-version 1.1;
  namespace "http://example.com/ns/example-newco-bgp";
  prefix example-newco-bgp;

  import ietf-bgp {
    prefix "bgp";
  }

  organization
    "Newco model group.";

  contact
    "abc@newco.com";
  description
    "This YANG module deviates IETF BGP YANG module.";

  revision 2022-10-13 {
    description
      "Creating NewCo deviations to ietf-bgp model";

    reference
      "RFC XXXX: BGP YANG module for Service Provider Network.";
  }

  deviation "/bgp:bgp/bgp:global/bgp:graceful-restart/" +
    "bgp:restart-time" {
    deviate not-supported;
  }

  deviation "/bgp:bgp/bgp:global/bgp:graceful-restart/" +
    "bgp:stale-route-time" {
    deviate not-supported;
  }
}
```

Appendix D. Complete configuration tree diagram

Here is a complete tree diagram for the configuration and operational part of the model.

module: ietf-bgp

augment /rt:routing/rt:control-plane-protocols
/rt:control-plane-protocol:

```
+--rw bgp
  +--rw global!
    | +--rw as inet:as-number
    | +--rw identifier? yang:dotted-quad
    | +--rw distance
    | | +--rw external? uint8
    | | +--rw internal? uint8
    | +--rw confederation
    | | +--rw enabled? boolean
    | | +--rw identifier? inet:as-number
    | | +--rw member-as* inet:as-number
    | +--rw graceful-restart {bt:graceful-restart}?
    | | +--rw enabled? boolean
    | | +--rw restart-time? uint16
    | | +--rw stale-routes-time? uint32
    | | +--rw helper-only? boolean
    | +--rw use-multiple-paths
    | | +--rw enabled? boolean
    | | +--rw ebgp
    | | | +--rw allow-multiple-as? boolean
    | | | +--rw maximum-paths? uint32
    | | +--rw ibgp
    | | | +--rw maximum-paths? uint32
    | +--rw route-selection-options
    | | +--rw always-compare-med? boolean
    | | +--rw ignore-as-path-length? boolean
    | | +--rw external-compare-router-id? boolean
    | | +--rw advertise-inactive-routes? boolean
    | | +--rw enable-aigp? boolean
    | | +--rw ignore-next-hop-igp-metric? boolean
    | | +--rw enable-med? boolean
    | | +--rw med-plus-igp
    | | | +--rw enabled? boolean
    | | | +--rw igp-multiplier? uint16
    | | | +--rw med-multiplier? uint16
    | +--rw afi-safis
    | | +--rw afi-safi* [name]
    | | | +--rw name identityref
    | | | +--rw enabled? boolean
    | | | +--ro statistics
    | | | | +--ro total-paths? yang:gauge32
    | | | | +--ro total-prefixes? yang:gauge32
    | | | +--rw graceful-restart {bt:graceful-restart}?
    | | | | +--rw enabled? boolean
    | | +--rw route-selection-options
```

```

| | | +--rw always-compare-med?          boolean
| | | +--rw ignore-as-path-length?       boolean
| | | +--rw external-compare-router-id?  boolean
| | | +--rw advertise-inactive-routes?   boolean
| | | +--rw enable-aigp?                 boolean
| | | +--rw ignore-next-hop-igp-metric?  boolean
| | | +--rw enable-med?                  boolean
| | | +--rw med-plus-igp
| | | | +--rw enabled?                   boolean
| | | | +--rw igp-multiplier?            uint16
| | | | +--rw med-multiplier?            uint16
| | +--rw use-multiple-paths
| | | +--rw enabled?                     boolean
| | | +--rw ebgp
| | | | +--rw allow-multiple-as?         boolean
| | | | +--rw maximum-paths?             uint32
| | | +--rw ibgp
| | | | +--rw maximum-paths?             uint32
| | +--rw apply-policy
| | | +--rw import-policy*                leafref
| | | +--rw default-import-policy?        default-policy-type
| | | +--rw export-policy*                leafref
| | | +--rw default-export-policy?        default-policy-type
| | +--rw ipv4-unicast
| | | +--rw prefix-limit
| | | | +--rw max-prefixes?               uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer?              uint32
| | | +--rw send-default-route?          boolean
| | +--rw ipv6-unicast
| | | +--rw prefix-limit
| | | | +--rw max-prefixes?               uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer?              uint32
| | | +--rw send-default-route?          boolean
| | +--rw ipv4-labeled-unicast
| | | +--rw prefix-limit
| | | | +--rw max-prefixes?               uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer?              uint32
| | +--rw ipv6-labeled-unicast
| | | +--rw prefix-limit
| | | | +--rw max-prefixes?               uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | +--rw restart-timer?              uint32

```

```

| | +--rw l3vpn-ipv4-unicast
| | | +--rw prefix-limit
| | | | +--rw max-prefixes? uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer? uint32
| | +--rw l3vpn-ipv6-unicast
| | | +--rw prefix-limit
| | | | +--rw max-prefixes? uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer? uint32
| | +--rw l3vpn-ipv4-multicast
| | | +--rw prefix-limit
| | | | +--rw max-prefixes? uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer? uint32
| | +--rw l3vpn-ipv6-multicast
| | | +--rw prefix-limit
| | | | +--rw max-prefixes? uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer? uint32
| | +--rw l2vpn-vpls
| | | +--rw prefix-limit
| | | | +--rw max-prefixes? uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer? uint32
| | +--rw l2vpn-evpn
| | | +--rw prefix-limit
| | | | +--rw max-prefixes? uint32
| | | | +--rw shutdown-threshold-pct?
| | | | | rt-types:percentage
| | | | +--rw restart-timer? uint32
| +--rw apply-policy
| | +--rw import-policy* leafref
| | +--rw default-import-policy? default-policy-type
| | +--rw export-policy* leafref
| | +--rw default-export-policy? default-policy-type
| +--ro statistics
| | +--ro total-paths? yang:gauge32
| | +--ro total-prefixes? yang:gauge32
+--rw neighbors
| +--rw neighbor* [remote-address]
| | +--rw remote-address inet:ip-address
| | +--ro local-address? inet:ip-address
| | +--ro local-port? inet:port-number

```

```

| | +--ro remote-port?          inet:port-number
| | +--ro peer-type?           bt:peer-type
| | +--rw peer-group?
| | |   -> ../../../../peer-groups/peer-group/name
| | +--ro identifier?          yang:dotted-quad
| | +--rw enabled?             boolean
| | +--rw secure-session-enable? boolean
| | +--rw secure-session
| | |   +--rw (option)?
| | |   |   +--:(ao)
| | |   |   |   +--rw ao-keychain?    key-chain:key-chain-ref
| | |   |   |   +--:(md5)
| | |   |   |   +--rw md5-keychain?    key-chain:key-chain-ref
| | +--rw ttl-security?        uint8
| | |   {bt:ttl-security}?
| | +--rw peer-as?             inet:as-number
| | +--rw local-as?            inet:as-number
| | +--rw remove-private-as?
| | |   bt:remove-private-as-option
| | +--rw route-flap-damping {bt:damping}?
| | |   +--rw enable?          boolean
| | |   +--rw suppress-above?   decimal64
| | |   +--rw reuse-above?      decimal64
| | |   +--rw max-flap?         decimal64
| | |   +--rw reach-decay?      uint32
| | |   +--rw unreach-decay?    uint32
| | |   +--rw keep-history?     uint32
| | +--rw send-community*      identityref
| | |   {bt:send-communities}?
| | +--rw description?         string
| | +--rw timers
| | |   +--rw connect-retry-interval?    uint16
| | |   +--rw hold-time?                  uint16
| | |   +--rw keepalive?                  uint16
| | |   +--rw min-as-origination-interval? uint16
| | |   +--rw min-route-advertisement-interval? uint16
| | +--rw transport
| | |   +--rw tcp-mss?          tcp:mss
| | |   +--rw mtu-discovery?    boolean
| | |   +--rw passive-mode?     boolean
| | |   +--rw local-address?    union
| | |   +--rw bfd {bt:bfd}?
| | |   |   +--rw enabled?          boolean
| | |   |   +--rw local-multiplier? multiplier
| | |   |   |   {client-base-cfg-parms}?
| | |   +--rw (interval-config-type)?
| | |   |   {client-base-cfg-parms}?
| | |   |   +--:(tx-rx-intervals)
| | |   |   |   +--rw desired-min-tx-interval?    uint32

```



```

| | | | +-rw required-min-rx-interval? uint32
| | | | +--:(single-interval)
| | | | {single-minimum-interval}?
| | | | +-rw min-interval? uint32
| | +--rw graceful-restart {bt:graceful-restart}?
| | | +--rw enabled? boolean
| | | +--rw restart-time? uint16
| | | +--rw stale-routes-time? uint32
| | | +--rw helper-only? boolean
| | | +--ro peer-restart-time? uint16
| | | +--ro peer-restarting? boolean
| | | +--ro local-restarting? boolean
| | | +--ro mode? enumeration
| | +--rw logging-options
| | | +--rw log-neighbor-state-changes? boolean
| | +--rw ebgp-multihop
| | | +--rw enabled? boolean
| | | +--rw multihop-ttl? uint8
| | +--rw route-reflector
| | | +--rw cluster-id? bt:rr-cluster-id-type
| | | +--rw no-client-reflect? boolean
| | | +--rw client? boolean
| | +--rw as-path-options
| | | +--rw allow-own-as? uint8
| | | +--rw replace-peer-as? boolean
| | +--rw add-paths {bt:add-paths}?
| | | +--rw receive? boolean
| | | +--rw (send)?
| | | | +--:(max)
| | | | | +--rw max? uint8
| | | | +--:(all)
| | | | | +--rw all? empty
| | | +--rw eligible-prefix-policy? leafref
| | +--rw use-multiple-paths
| | | +--rw enabled? boolean
| | | +--rw ebgp
| | | | +--rw allow-multiple-as? boolean
| | +--rw apply-policy
| | | +--rw import-policy* leafref
| | | +--rw default-import-policy? default-policy-type
| | | +--rw export-policy* leafref
| | | +--rw default-export-policy? default-policy-type
| | +--rw afi-safis
| | | +--rw afi-safi* [name]
| | | | +--rw name identityref
| | | | +--rw enabled? boolean
| | | | +--ro active? boolean
| | | | +--ro prefixes
| | | | +--ro received? yang:counter32

```

				+-ro sent?	yang:counter32
				+-ro installed?	yang:counter32
				+-rw graceful-restart {bt:graceful-restart}?	
				+-rw enabled?	
					boolean
				+-ro received?	
					boolean
				+-ro advertised?	
					boolean
				+-ro local-forwarding-state-preserved?	
					boolean
				+-ro forwarding-state-preserved?	
					boolean
				+-ro end-of-rib-received?	
					boolean
				+-rw apply-policy	
				+-rw import-policy*	leafref
				+-rw default-import-policy?	
					default-policy-type
				+-rw export-policy*	leafref
				+-rw default-export-policy?	
					default-policy-type
				+-rw ipv4-unicast	
				+-rw prefix-limit	
					+-rw max-prefixes? uint32
					+-rw shutdown-threshold-pct?
					rt-types:percentage
					+-rw restart-timer? uint32
				+-rw send-default-route?	boolean
				+-rw ipv6-unicast	
				+-rw prefix-limit	
					+-rw max-prefixes? uint32
					+-rw shutdown-threshold-pct?
					rt-types:percentage
					+-rw restart-timer? uint32
				+-rw send-default-route?	boolean
				+-rw ipv4-labeled-unicast	
				+-rw prefix-limit	
				+-rw max-prefixes?	uint32
				+-rw shutdown-threshold-pct?	
					rt-types:percentage
				+-rw restart-timer?	uint32
				+-rw ipv6-labeled-unicast	
				+-rw prefix-limit	
				+-rw max-prefixes?	uint32
				+-rw shutdown-threshold-pct?	
					rt-types:percentage
				+-rw restart-timer?	uint32
				+-rw l3vpn-ipv4-unicast	

				+--rw prefix-limit	
				+--rw max-prefixes?	uint32
				+--rw shutdown-threshold-pct?	
					rt-types:percentage
				+--rw restart-timer?	uint32
				+--rw l3vpn-ipv6-unicast	
				+--rw prefix-limit	
				+--rw max-prefixes?	uint32
				+--rw shutdown-threshold-pct?	
					rt-types:percentage
				+--rw restart-timer?	uint32
				+--rw l3vpn-ipv4-multicast	
				+--rw prefix-limit	
				+--rw max-prefixes?	uint32
				+--rw shutdown-threshold-pct?	
					rt-types:percentage
				+--rw restart-timer?	uint32
				+--rw l3vpn-ipv6-multicast	
				+--rw prefix-limit	
				+--rw max-prefixes?	uint32
				+--rw shutdown-threshold-pct?	
					rt-types:percentage
				+--rw restart-timer?	uint32
				+--rw l2vpn-vpls	
				+--rw prefix-limit	
				+--rw max-prefixes?	uint32
				+--rw shutdown-threshold-pct?	
					rt-types:percentage
				+--rw restart-timer?	uint32
				+--rw l2vpn-evpn	
				+--rw prefix-limit	
				+--rw max-prefixes?	uint32
				+--rw shutdown-threshold-pct?	
					rt-types:percentage
				+--rw restart-timer?	uint32
				+--rw use-multiple-paths	
				+--rw enabled?	boolean
				+--rw ebgp	
				+--rw allow-multiple-as?	boolean
				+--rw session-state?	enumeration
				+--ro last-established?	yang:date-and-time
				+--ro negotiated-capabilities*	identityref
				+--ro negotiated-hold-time?	uint16
				+--ro last-error?	binary
				+--ro fsm-established-time?	yang:gauge32
				+--rw treat-as-withdraw?	boolean
				+--ro erroneous-update-messages?	uint32
				+--rw bfd {bt:bfd}?	
				+--rw enabled?	boolean

```

| | | +--rw local-multiplier? multiplier
| | | | {client-base-cfg-parms}?
| | | +--rw (interval-config-type)?
| | | | {client-base-cfg-parms}?
| | | | +--:(tx-rx-intervals)
| | | | | +--rw desired-min-tx-interval? uint32
| | | | | +--rw required-min-rx-interval? uint32
| | | | +--:(single-interval) {single-minimum-interval}?
| | | | +--rw min-interval? uint32
| | +--ro statistics
| | | +--ro peer-fsm-established-transitions?
| | | | yang:zero-based-counter64
| | | +--ro fsm-established-transitions?
| | | | yang:zero-based-counter32
| | +--ro messages
| | | +--ro in-total-messages?
| | | | yang:zero-based-counter32
| | | +--ro out-total-messages?
| | | | yang:zero-based-counter32
| | | +--ro in-update-elapsed-time? yang:gauge32
| | | +--ro sent
| | | | +--ro updates-received?
| | | | | yang:zero-based-counter64
| | | | +--ro updates-sent?
| | | | | yang:zero-based-counter64
| | | | +--ro messages-received?
| | | | | yang:zero-based-counter64
| | | | +--ro messages-sent?
| | | | | yang:zero-based-counter64
| | | | +--ro notification?
| | | | | yang:zero-based-counter64
| | | +--ro received
| | | | +--ro updates-received?
| | | | | yang:zero-based-counter64
| | | | +--ro updates-sent?
| | | | | yang:zero-based-counter64
| | | | +--ro messages-received?
| | | | | yang:zero-based-counter64
| | | | +--ro messages-sent?
| | | | | yang:zero-based-counter64
| | | | +--ro notification?
| | | | | yang:zero-based-counter64
| | +--ro queues
| | | +--ro input? yang:counter32
| | | +--ro output? yang:counter32
| | +---x clear {bt:clear-statistics}?
| | | +---w input
| | | | +---w clear-at? yang:date-and-time
| | | +--ro output

```

```

| |         +--ro clear-finished-at?   yang:date-and-time
| +---n established
| | +-- remote-address?   -> ../../neighbor/remote-address
| | +-- last-error?       -> ../../neighbor/last-error
| | +-- session-state?    -> ../../neighbor/session-state
| +---n backward-transition
| | +-- remote-addr?      -> ../../neighbor/remote-address
| | +-- last-error?       -> ../../neighbor/last-error
| | +-- session-state?    -> ../../neighbor/session-state
| +---x clear {bt:clear-neighbors}?
|   +---w input
|     | +---w (operation)?
|     | | +--:(operation-admin)
|     | | | +--w admin?      empty
|     | | | +--:(operation-hard)
|     | | | +--w hard?      empty
|     | | | +--:(operation-soft)
|     | | | +--w soft?      empty
|     | | | +--:(operation-soft-inbound)
|     | |   +---w soft-inbound? empty {bt:route-refresh}?
|     |   +---w clear-at?    yang:date-and-time
|   +---ro output
|     +--ro clear-finished-at?  yang:date-and-time
+---rw peer-groups
| +---rw peer-group* [name]
|   +---rw name                string
|   +---rw secure-session-enable? boolean
|   +---rw secure-session
|     | +---rw (option)?
|     |   +--:(ao)
|     |   | +---rw ao-keychain?  key-chain:key-chain-ref
|     |   | +--:(md5)
|     |   | | +---rw md5-keychain? key-chain:key-chain-ref
|     |   | | +--:(ipsec)
|     |   |   +---rw sa?          string
|   +---rw ttl-security?        uint8 {bt:ttl-security}?
|   +---rw peer-as?              inet:as-number
|   +---rw local-as?             inet:as-number
|   +---rw remove-private-as?
|     | bt:remove-private-as-option
|   +---rw route-flap-damping {bt:damping}?
|     | +---rw enable?           boolean
|     | +---rw suppress-above?   decimal64
|     | +---rw reuse-above?      decimal64
|     | +---rw max-flap?         decimal64
|     | +---rw reach-decay?      uint32
|     | +---rw unreach-decay?    uint32
|     | +---rw keep-history?     uint32
|   +---rw send-community*       identityref

```

```

|         {bt:send-communities}?
| +--rw description?          string
| +--rw timers
| |   +--rw connect-retry-interval?      uint16
| |   +--rw hold-time?                  uint16
| |   +--rw keepalive?                  uint16
| |   +--rw min-as-origination-interval?  uint16
| |   +--rw min-route-advertisement-interval?  uint16
| +--rw transport
| |   +--rw tcp-mss?          tcp:mss
| |   +--rw mtu-discovery?    boolean
| |   +--rw passive-mode?     boolean
| |   +--rw local-address?    union
| |   +--rw bfd {bt:bfd}?
| |   |   +--rw enabled?          boolean
| |   |   +--rw local-multiplier? multiplier
| |   |   |   {client-base-cfg-parms}?
| |   |   +--rw (interval-config-type)?
| |   |   |   {client-base-cfg-parms}?
| |   |   |   +--:(tx-rx-intervals)
| |   |   |   |   +--rw desired-min-tx-interval?  uint32
| |   |   |   |   +--rw required-min-rx-interval?  uint32
| |   |   |   +--:(single-interval)
| |   |   |   |   {single-minimum-interval}?
| |   |   |   +--rw min-interval?          uint32
| +--rw graceful-restart {bt:graceful-restart}?
| |   +--rw enabled?          boolean
| |   +--rw restart-time?      uint16
| |   +--rw stale-routes-time? uint32
| |   +--rw helper-only?      boolean
| |   +--ro peer-restart-time? uint16
| |   +--ro peer-restarting?   boolean
| |   +--ro local-restarting?   boolean
| |   +--ro mode?              enumeration
| +--rw logging-options
| |   +--rw log-neighbor-state-changes?  boolean
| +--rw ebgp-multihop
| |   +--rw enabled?          boolean
| |   +--rw multihop-ttl?    uint8
| +--rw route-reflector
| |   +--rw cluster-id?        bt:rr-cluster-id-type
| |   +--rw no-client-reflect?  boolean
| |   +--rw client?            boolean
| +--rw as-path-options
| |   +--rw allow-own-as?      uint8
| |   +--rw replace-peer-as?   boolean
| +--rw add-paths {bt:add-paths}?
| |   +--rw receive?          boolean
| |   +--rw (send)?

```

```

|   |   | +--:(max)
|   |   | | +--rw max?                uint8
|   |   | +--:(all)
|   |   | | +--rw all?                empty
|   | +--rw eligible-prefix-policy?  leafref
| +--rw use-multiple-paths
|   | +--rw enabled?    boolean
|   | +--rw ebgp
|   | | +--rw allow-multiple-as?    boolean
| +--rw apply-policy
|   | +--rw import-policy*          leafref
|   | +--rw default-import-policy?  default-policy-type
|   | +--rw export-policy*          leafref
|   | +--rw default-export-policy?  default-policy-type
| +--rw afi-safis
|   +--rw afi-safi* [name]
|       +--rw name                identityref
|       +--rw enabled?            boolean
|       +--rw graceful-restart {bt:graceful-restart}?
|       | +--rw enabled?    boolean
|       +--rw use-multiple-paths
|       | +--rw enabled?    boolean
|       | +--rw ebgp
|       | | +--rw allow-multiple-as?    boolean
|       +--rw apply-policy
|       | +--rw import-policy*          leafref
|       | +--rw default-import-policy?
|       | | default-policy-type
|       | +--rw export-policy*          leafref
|       | +--rw default-export-policy?
|       | | default-policy-type
|       +--rw ipv4-unicast
|       | +--rw prefix-limit
|       | | +--rw max-prefixes?          uint32
|       | | +--rw shutdown-threshold-pct?
|       | | | rt-types:percentage
|       | | +--rw restart-timer?          uint32
|       | +--rw send-default-route?    boolean
|       +--rw ipv6-unicast
|       | +--rw prefix-limit
|       | | +--rw max-prefixes?          uint32
|       | | +--rw shutdown-threshold-pct?
|       | | | rt-types:percentage
|       | | +--rw restart-timer?          uint32
|       | +--rw send-default-route?    boolean
|       +--rw ipv4-labeled-unicast
|       | +--rw prefix-limit
|       | | +--rw max-prefixes?          uint32
|       | | +--rw shutdown-threshold-pct?

```

```

|         |         |         rt-types:percentage
|         |         +--rw restart-timer?         uint32
|         +--rw ipv6-labeled-unicast
|         |         +--rw prefix-limit
|         |         +--rw max-prefixes?         uint32
|         |         +--rw shutdown-threshold-pct?
|         |         |         rt-types:percentage
|         |         +--rw restart-timer?         uint32
|         +--rw l3vpn-ipv4-unicast
|         |         +--rw prefix-limit
|         |         +--rw max-prefixes?         uint32
|         |         +--rw shutdown-threshold-pct?
|         |         |         rt-types:percentage
|         |         +--rw restart-timer?         uint32
|         +--rw l3vpn-ipv6-unicast
|         |         +--rw prefix-limit
|         |         +--rw max-prefixes?         uint32
|         |         +--rw shutdown-threshold-pct?
|         |         |         rt-types:percentage
|         |         +--rw restart-timer?         uint32
|         +--rw l3vpn-ipv4-multicast
|         |         +--rw prefix-limit
|         |         +--rw max-prefixes?         uint32
|         |         +--rw shutdown-threshold-pct?
|         |         |         rt-types:percentage
|         |         +--rw restart-timer?         uint32
|         +--rw l3vpn-ipv6-multicast
|         |         +--rw prefix-limit
|         |         +--rw max-prefixes?         uint32
|         |         +--rw shutdown-threshold-pct?
|         |         |         rt-types:percentage
|         |         +--rw restart-timer?         uint32
|         +--rw l2vpn-vpls
|         |         +--rw prefix-limit
|         |         +--rw max-prefixes?         uint32
|         |         +--rw shutdown-threshold-pct?
|         |         |         rt-types:percentage
|         |         +--rw restart-timer?         uint32
|         +--rw l2vpn-evpn
|         |         +--rw prefix-limit
|         |         +--rw max-prefixes?         uint32
|         |         +--rw shutdown-threshold-pct?
|         |         |         rt-types:percentage
|         |         +--rw restart-timer?         uint32
+--rw interfaces
|   +--rw interface* [name]
|     +--rw name      if:interface-ref
|     +--rw bfd {bt:bfd}?
|     +--rw enabled?  boolean

```



```

+--ro rib
  +--ro attr-sets
  | +--ro attr-set* [index]
  |   +--ro index          uint64
  |   +--ro attributes
  |     +--ro origin?
  |       | bt:bgp-origin-attr-type
  |     +--ro atomic-aggregate?    boolean
  |     +--ro next-hop?            inet:ip-address
  |     +--ro link-local-next-hop? inet:ipv6-address
  |     +--ro med?                  uint32
  |     +--ro local-pref?           uint32
  |     +--ro originator-id?       yang:dotted-quad
  |     +--ro cluster-list*        yang:dotted-quad
  |     +--ro aigp-metric?         uint64
  |     +--ro aggregator
  |       | +--ro as?            inet:as-number
  |       | +--ro address?      inet:ipv4-address
  |     +--ro aggregator4
  |       | +--ro as4?          inet:as-number
  |       | +--ro address?      inet:ipv4-address
  |     +--ro as-path
  |       | +--ro segment* []
  |       |   +--ro type?      identityref
  |       |   +--ro member*    inet:as-number
  |     +--ro as4-path
  |       +--ro segment* []
  |         +--ro type?      identityref
  |         +--ro member*    inet:as-number
+--ro communities
  | +--ro community* [index]
  |   +--ro index          uint64
  |   +--ro community*     union
+--ro ext-communities
  | +--ro ext-community* [index]
  |   +--ro index          uint64
  |   +--ro ext-community* bt:bgp-ext-community-type
  |   +--ro ext-community-raw* string
+--ro large-communities
  | +--ro large-community* [index]
  |   +--ro index          uint64
  |   +--ro large-community* bt:bgp-large-community-type
+--ro afi-safis
  +--ro afi-safi* [name]
  |   +--ro name            identityref
  |   +--ro ipv4-unicast
  |     | +--ro loc-rib
  |     | | +--ro routes
  |     | |   +--ro route* [prefix origin path-id]

```

```

| |      +--ro prefix
| |      |      inet:ipv4-prefix
| |      +--ro origin          union
| |      +--ro path-id         uint32
| |      +--ro attr-index?     leafref
| |      +--ro community-index? leafref
| |      +--ro ext-community-index? leafref
| |      +--ro last-modified?
| |      |      yang:timeticks
| |      +--ro eligible-route?  boolean
| |      +--ro ineligible-reason? identityref
| |      +--ro unknown-attributes
| |      |      +--ro unknown-attribute* [attr-type]
| |      |      |      +--ro optional?    boolean
| |      |      |      +--ro transitive?  boolean
| |      |      |      +--ro partial?    boolean
| |      |      |      +--ro extended?   boolean
| |      |      |      +--ro attr-type   uint8
| |      |      |      +--ro attr-len?   uint16
| |      |      |      +--ro attr-value? binary
| |      +--ro reject-reason?    union
| +--ro neighbors
|   +--ro neighbor* [neighbor-address]
|     +--ro neighbor-address  inet:ip-address
|     +--ro adj-rib-in-pre
|       +--ro routes
|         +--ro route* [prefix path-id]
|           +--ro prefix
|             inet:ipv4-prefix
|           +--ro path-id          uint32
|           +--ro attr-index?     leafref
|           +--ro community-index? leafref
|           +--ro ext-community-index? leafref
|           +--ro last-modified?
|           |      yang:timeticks
|           +--ro eligible-route?
|           |      boolean
|           +--ro ineligible-reason?
|           |      identityref
|           +--ro unknown-attributes
|           |      +--ro unknown-attribute*
|           |      |      [attr-type]
|           |      |      +--ro optional?    boolean
|           |      |      +--ro transitive?  boolean
|           |      |      +--ro partial?    boolean
|           |      |      +--ro extended?   boolean
|           |      |      +--ro attr-type   uint8
|           |      |      +--ro attr-len?   uint16
|           |      |      +--ro attr-value? binary

```

```

|   |   |   +--ro reject-reason?          union
|   |   | +--ro clear-routes {bt:clear-routes}?
|   |   |   +---x clear
|   |   |       +---w input
|   |   |           | +---w clear-at?
|   |   |           |         yang:date-and-time
|   |   |   +--ro output
|   |   |       +--ro clear-finished-at?
|   |   |           yang:date-and-time
|   | +--ro adj-rib-in-post
|   |   +--ro routes
|   |       | +--ro route* [prefix path-id]
|   |       |   +--ro prefix
|   |       |       | inet:ipv4-prefix
|   |       |   +--ro path-id          uint32
|   |       |   +--ro attr-index?      leafref
|   |       |   +--ro community-index? leafref
|   |       |   +--ro ext-community-index? leafref
|   |       |   +--ro last-modified?
|   |       |       | yang:timeticks
|   |       |   +--ro eligible-route?
|   |       |       | boolean
|   |       |   +--ro ineligible-reason?
|   |       |       | identityref
|   |       |   +--ro best-path?
|   |       |       | boolean
|   |       |   +--ro unknown-attributes
|   |       |       | +--ro unknown-attribute*
|   |       |           | [attr-type]
|   |       |           |   +--ro optional?    boolean
|   |       |           |   +--ro transitive?  boolean
|   |       |           |   +--ro partial?     boolean
|   |       |           |   +--ro extended?    boolean
|   |       |           |   +--ro attr-type    uint8
|   |       |           |   +--ro attr-len?    uint16
|   |       |           |   +--ro attr-value?  binary
|   |       |   +--ro reject-reason?          union
|   |   +--ro clear-routes {bt:clear-routes}?
|   |       +---x clear
|   |           +---w input
|   |               | +---w clear-at?
|   |               |         yang:date-and-time
|   |       +--ro output
|   |           +--ro clear-finished-at?
|   |               yang:date-and-time
|   +--ro adj-rib-out-pre
|       | +--ro routes
|       |   | +--ro route* [prefix path-id]
|       |   |   +--ro prefix

```

```

| | | | inet:ipv4-prefix
| | | +--ro path-id uint32
| | | +--ro attr-index? leafref
| | | +--ro community-index? leafref
| | | +--ro ext-community-index? leafref
| | | +--ro last-modified?
| | | | yang:timeticks
| | | +--ro eligible-route?
| | | | boolean
| | | +--ro ineligible-reason?
| | | | identityref
| | | +--ro unknown-attributes
| | | | +--ro unknown-attribute*
| | | | [attr-type]
| | | | +--ro optional? boolean
| | | | +--ro transitive? boolean
| | | | +--ro partial? boolean
| | | | +--ro extended? boolean
| | | | +--ro attr-type uint8
| | | | +--ro attr-len? uint16
| | | | +--ro attr-value? binary
| | | +--ro reject-reason? union
| +--ro clear-routes {bt:clear-routes}?
| | +---x clear
| | | +---w input
| | | | +---w clear-at?
| | | | | yang:date-and-time
| | | +--ro output
| | | | +--ro clear-finished-at?
| | | | | yang:date-and-time
+--ro adj-rib-out-post
+--ro routes
| | +--ro route* [prefix path-id]
| | | +--ro prefix
| | | | inet:ipv4-prefix
| | | +--ro path-id uint32
| | | +--ro attr-index? leafref
| | | +--ro community-index? leafref
| | | +--ro ext-community-index? leafref
| | | +--ro last-modified?
| | | | yang:timeticks
| | | +--ro eligible-route?
| | | | boolean
| | | +--ro ineligible-reason?
| | | | identityref
| | | +--ro unknown-attributes
| | | | +--ro unknown-attribute*
| | | | [attr-type]
| | | | +--ro optional? boolean

```

```

|         |         |         +--ro transitive?    boolean
|         |         |         +--ro partial?      boolean
|         |         |         +--ro extended?     boolean
|         |         |         +--ro attr-type      uint8
|         |         |         +--ro attr-len?      uint16
|         |         |         +--ro attr-value?    binary
|         |         +--ro reject-reason?          union
|         +--ro clear-routes {bt:clear-routes}?
|             +---x clear
|                 +---w input
|                     | +---w clear-at?
|                     |         yang:date-and-time
|                 +--ro output
|                     +--ro clear-finished-at?
|                         yang:date-and-time
+--ro ipv6-unicast
+--ro loc-rib
|   +--ro routes
|       +--ro route* [prefix origin path-id]
|           +--ro prefix
|               |       inet:ipv6-prefix
|           +--ro origin          union
|           +--ro path-id         uint32
|           +--ro attr-index?     leafref
|           +--ro community-index? leafref
|           +--ro ext-community-index? leafref
|           +--ro last-modified?
|               |       yang:timeticks
|           +--ro eligible-route? boolean
|           +--ro ineligible-reason? identityref
|           +--ro unknown-attributes
|               | +--ro unknown-attribute* [attr-type]
|                   | +--ro optional?    boolean
|                   | +--ro transitive?  boolean
|                   | +--ro partial?     boolean
|                   | +--ro extended?    boolean
|                   | +--ro attr-type     uint8
|                   | +--ro attr-len?    uint16
|                   | +--ro attr-value?   binary
|                   +--ro reject-reason?  union
+--ro neighbors
+--ro neighbor* [neighbor-address]
+--ro neighbor-address    inet:ip-address
+--ro adj-rib-in-pre
|   +--ro routes
|       | +--ro route* [prefix path-id]
|       |     +--ro prefix
|       |         |       inet:ipv6-prefix
|       |         +--ro path-id          uint32

```

```

| | +--ro attr-index? leafref
| | +--ro community-index? leafref
| | +--ro ext-community-index? leafref
| | +--ro last-modified?
| | | yang:timeticks
| | +--ro eligible-route?
| | | boolean
| | +--ro ineligible-reason?
| | | identityref
| | +--ro unknown-attributes
| | | +--ro unknown-attribute*
| | | | [attr-type]
| | | | +--ro optional? boolean
| | | | +--ro transitive? boolean
| | | | +--ro partial? boolean
| | | | +--ro extended? boolean
| | | | +--ro attr-type uint8
| | | | +--ro attr-len? uint16
| | | | +--ro attr-value? binary
| | +--ro reject-reason? union
| +--ro clear-routes {bt:clear-routes}?
| | +---x clear
| | | +---w input
| | | | +---w clear-at?
| | | | | yang:date-and-time
| | | +--ro output
| | | | +--ro clear-finished-at?
| | | | | yang:date-and-time
+--ro adj-rib-in-post
| | +--ro routes
| | | +--ro route* [prefix path-id]
| | | | +--ro prefix
| | | | | inet:ipv6-prefix
| | | | +--ro path-id uint32
| | | | +--ro attr-index? leafref
| | | | +--ro community-index? leafref
| | | | +--ro ext-community-index? leafref
| | | | +--ro last-modified?
| | | | | yang:timeticks
| | | | +--ro eligible-route?
| | | | | boolean
| | | | +--ro ineligible-reason?
| | | | | identityref
| | | | +--ro best-path?
| | | | | boolean
| | | | +--ro unknown-attributes
| | | | | +--ro unknown-attribute*
| | | | | | [attr-type]
| | | | | +--ro optional? boolean

```

```

| | | +--ro transitive?    boolean
| | | +--ro partial?      boolean
| | | +--ro extended?     boolean
| | | +--ro attr-type     uint8
| | | +--ro attr-len?     uint16
| | | +--ro attr-value?   binary
| | +--ro reject-reason?  union
| +--ro clear-routes {bt:clear-routes}?
|   +---x clear
|     +---w input
|       | +---w clear-at?
|       |   yang:date-and-time
|     +--ro output
|       +--ro clear-finished-at?
|         yang:date-and-time
+--ro adj-rib-out-pre
| +--ro routes
| | +--ro route* [prefix path-id]
| |   +--ro prefix
| |     | inet:ipv6-prefix
| |   +--ro path-id      uint32
| |   +--ro attr-index?  leafref
| |   +--ro community-index?  leafref
| |   +--ro ext-community-index?  leafref
| |   +--ro last-modified?
| |     | yang:timeticks
| |   +--ro eligible-route?
| |     | boolean
| |   +--ro ineligible-reason?
| |     | identityref
| |   +--ro unknown-attributes
| |     | +--ro unknown-attribute*
| |       | [attr-type]
| |       | +--ro optional?    boolean
| |       | +--ro transitive?  boolean
| |       | +--ro partial?     boolean
| |       | +--ro extended?    boolean
| |       | +--ro attr-type    uint8
| |       | +--ro attr-len?    uint16
| |       | +--ro attr-value?  binary
| |       +--ro reject-reason?  union
| +--ro clear-routes {bt:clear-routes}?
|   +---x clear
|     +---w input
|       | +---w clear-at?
|       |   yang:date-and-time
|     +--ro output
|       +--ro clear-finished-at?
|         yang:date-and-time

```

```

+--ro adj-rib-out-post
  +--ro routes
    | +--ro route* [prefix path-id]
    |   +--ro prefix
    |     | inet:ipv6-prefix
    |   +--ro path-id          uint32
    |   +--ro attr-index?      leafref
    |   +--ro community-index? leafref
    |   +--ro ext-community-index? leafref
    |   +--ro last-modified?
    |     | yang:timeticks
    |   +--ro eligible-route?
    |     | boolean
    |   +--ro ineligible-reason?
    |     | identityref
    |   +--ro unknown-attributes
    |     | +--ro unknown-attribute*
    |       | [attr-type]
    |       |   +--ro optional?    boolean
    |       |   +--ro transitive?  boolean
    |       |   +--ro partial?     boolean
    |       |   +--ro extended?    boolean
    |       |   +--ro attr-type    uint8
    |       |   +--ro attr-len?    uint16
    |       |   +--ro attr-value?  binary
    |   +--ro reject-reason?      union
  +--ro clear-routes {bt:clear-routes}?
    +---x clear
      +---w input
        | +---w clear-at?
        |   yang:date-and-time
      +--ro output
        +--ro clear-finished-at?
          yang:date-and-time

```


Appendix E. Complete policy tree diagram

Here is a complete tree diagram for the policy portion of the model.

```
module: ietf-bgp-policy
```

```
augment /rt-pol:routing-policy/rt-pol:defined-sets:
```

```
+--rw bgp-defined-sets
  +--rw community-sets
    | +--rw community-set* [name]
    |   +--rw name          string
    |   +--rw member*       union
  +--rw ext-community-sets
    | +--rw ext-community-set* [name]
    |   +--rw name          string
    |   +--rw member*       union
  +--rw large-community-sets
    | +--rw large-community-set* [name]
    |   +--rw name          string
    |   +--rw member*       union
  +--rw as-path-sets
    | +--rw as-path-set* [name]
    |   +--rw name          string
    |   +--rw member*       string
  +--rw next-hop-sets
    +--rw next-hop-set* [name]
      +--rw name          string
      +--rw next-hop*     bgp-next-hop-type
```

```
augment /rt-pol:routing-policy/rt-pol:policy-definitions
  /rt-pol:policy-definition/rt-pol:statements
  /rt-pol:statement/rt-pol:conditions:
```

```
+--rw bgp-conditions
  +--rw med-eq?                uint32
  +--rw origin-eq?            bt:bgp-origin-attr-type
  +--rw match-afi-safi
    | +--rw afi-safi-in*       identityref
    | +--rw match-set-options? match-set-options-type
  +--rw local-pref-eq?         uint32
  +--rw match-neighbor
    | +--rw neighbor-eq*       inet:ip-address
    | +--rw match-set-options? match-set-options-type
  +--rw route-type?            enumeration
  +--rw community-count
    | +--rw community-count?   uint32
    | +--rw (operation)?
    |   +--:(eq)
    |     | +--rw eq?          empty
    |     +--:(lt-or-eq)
    |       | +--rw lt-or-eq?   empty
    |       +--:(gt-or-eq)
    |         +--rw gt-or-eq?    empty
  +--rw as-path-length
    | +--rw as-path-length?    uint32
```

```

|   +--rw (operation)?
|   |   +--:(eq)
|   |   |   +--rw eq?          empty
|   |   +--:(lt-or-eq)
|   |   |   +--rw lt-or-eq?    empty
|   |   +--:(gt-or-eq)
|   |   |   +--rw gt-or-eq?    empty
+--rw match-community-set
|   +--rw community-set?      leafref
|   +--rw match-set-options?  match-set-options-type
+--rw match-ext-community-set
|   +--rw ext-community-set?  leafref
|   +--rw match-set-options?  match-set-options-type
+--rw match-large-community-set
|   +--rw large-community-set? leafref
|   +--rw match-set-options?  match-set-options-type
+--rw match-as-path-set
|   +--rw as-path-set?        leafref
|   +--rw match-set-options?  match-set-options-type
+--rw match-next-hop-set
|   +--rw next-hop-set?       leafref
|   +--rw match-set-options?  match-set-options-type
augment /rt-pol:routing-policy/rt-pol:policy-definitions
        /rt-pol:policy-definition/rt-pol:statements
        /rt-pol:statement/rt-pol:actions:
+--rw bgp-actions
|   +--rw set-route-origin?    bt:bgp-origin-attr-type
|   +--rw set-local-pref?      uint32
|   +--rw set-next-hop?        bgp-next-hop-type
|   +--rw set-med?             bgp-set-med-type
+--rw set-as-path-prepend
|   +--rw repeat-n?            uint8
|   +--rw asn*                 inet:as-number
+--rw set-community
|   +--rw options?
|   |   bgp-set-community-option-type
|   +--rw (method)?
|   |   +--:(inline)
|   |   |   +--rw communities*      union
|   |   +--:(reference)
|   |   |   +--rw community-set-ref? leafref
+--rw set-ext-community
|   +--rw options?
|   |   bgp-set-community-option-type
|   +--rw (method)?
|   |   +--:(inline)
|   |   |   +--rw communities*      rt-types:route-target
|   |   +--:(reference)
|   |   |   +--rw ext-community-set-ref? leafref

```

```
+--rw set-large-community
  +--rw options?
  |      bgp-set-community-option-type
+--rw (method)?
  +--:(inline)
  |   +--rw communities*
  |       bt:bgp-large-community-type
  +--:(reference)
      +--rw large-community-set-ref?   leafref
```

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