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                  BGP Extended Community for QoS Marking
                      draft-knoll-idr-qos-attribute-11

Abstract

   This document specifies a simple signalling mechanism for inter-
   domain QoS marking using several instances of a new BGP Extended
   Community. Class based packet marking and forwarding is currently
   performed independently within ASes. The new QoS marking community
   makes the targeted Per Hop Behaviour within the IP prefix advertising
   AS and the currently applied marking at the interconnection point
   known to all access and transit ASes. This enables individual
   (re-)marking and possibly forwarding treatment adaptation to the
   original QoS class setup of the respective originating AS. The
   extended community provides the means to signal QoS markings on
   different layers, which are linked together in QoS Class Sets. It
   provides inter-domain and cross-layer insight into the QoS class
   mapping of the source AS with minimal signalling traffic.

Requirements Language

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in RFC 2119 [RFC2119].

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Table of Contents

1. **Introduction**

   A new BGP Extended Community is defined in this document, which
   carries QoS marking information for different network layer
   technologies across ASes. This extended community is called "QoS
   Marking". This new community provides a mechanism within BGP-4
   [RFC4271] for associating all advertised prefixes of the AS with its
   differentiated QoS Class Marking information. It allows for the
   consistent exchange of class encoding values between BGP peers for
   physical, data link and network QoS mechanisms. These labels can be
   used to control the distribution of this information, for the
   encoding and for treatment adjustments within the AS or for other
   applications. One globally seen QoS Class Set per AS is required for
   scalability reasons. It is the AS provider's responsibility to
   enforce the globally signalled Set throughout the AS.

   Several QoS Marking communities MAY be included in a single BGP
   UPDATE message. They are virtually linked together by means of an
   identical "QoS Set Number" field. Each QoS Marking community is
   encoded as 8-octet tuple, as defined in Section 4. Signalled QoS
   Class Sets are assumed to be valid for traffic crossing this AS. If
   different QoS strategies are used with an AS, its provider is
   responsible for consistent transport of transit traffic across this
   inhomogeneous domain. In all transit forwarding cases, QoS based
   tunnelling mechanisms are the means of choice for transparent traffic
   transport.

   The availability of the "Best Effort" forwarding class is implied and
   defaults to a zero encoding on all signalled layers. It is therefore
   not necessary to include QoS Marking communities for the Best Effort
   Class as long as the default encoding is in place.

   Class overload prevention can be achieved by means of the signalling
   described in [I-D.knoll-idr-cos-interconnect]. It is a complementary
   concept to limit the usage of advertised classes in a fair and square
   manner.

2. **Problem Statement**

   Current inter-domain interconnection is "best effort" interconnection
   only. That is, traffic forwarding between ASes is without traffic
   class differentiation and without any forwarding guarantee. It is
   common for network providers to reset any IP packet class markings to
   zero, the best effort DSCP marking, at the AS ingress router, which
   eliminates any traffic differentiation. Some providers perform
   higher layer classification at the ingress in order to guess the
   forwarding requirements and to match on their AS internal QoS

forwarding policy. There is no standardized set of classes, no
standardized marking (class encoding) and no standardized forwarding
behaviour, which cross-domain traffic could rely on. QoS policy
decisions are taken by network providers independently and in an
uncoordinated fashion.

This general statement does not cover the existing individual
agreements, which do offer quality based interconnection with strict
QoS guarantees. However, such SLA based agreements are of bilateral
or multilateral nature and do not offer a means for a general "better
than best effort" interconnection. This draft does not aim for
making such SLA based agreements become void. On the contrary, those
agreements are expected to exist for special traffic forwarding paths
with strictly guaranteed QoS.

There are many approaches, which propose proper inter-domain QoS
strategies including inter-domain parameter signalling, metering,
monitoring and misbehaviour detection. Such complex strategies get
close to guaranteed QoS based forwarding at the expense of dynamic
measurements and adjustments, of state keeping on resource usage vs.
traffic load and in particular of possibly frequent inter-domain
signalling.

The proposed QoS Class marking approach dissociates from the complex
latter solutions and targets the general "better than best effort"
interconnection in coexistence with SLA based agreements. It enables
ASes to make their supported Class Sets and their encoding globally
known. In other words, this support information constitutes a simple
map of QoS enabled roads in transit and destination ASes.

Signalling the coarse information about the supported class set and
its cross-layer encoding within the involved forwarding domains of
the selected AS path removes the lack of knowledge about the over-all
available traffic differentiation. AS providers are enabled to make
an informed decision about supported class encodings and might adopt
to them. No guarantees are offered by this "better than best effort"
approach, but as much as easily possible traffic differentiation
without the need for frequent inter-domain signalling and for costly
ingress re-classification will be achieved.

Remarking the class encoding of customer traffic in order to match
neighbouring class set encodings is reasonable at AS interconnection
points. For AS internal forwarding, the encapsulation within any
kind of QoS supporting tunnelling technology is highly recommended.
The cross-layer signalling of QoS encoding will further ease the
setup of QoS based inter-domain tunnelling.

The general confidentiality concern of disclosing AS internal policy

information is addressed in Section 6. In short, network providers
can signal a different class set in the QoS Marking communities to
the one actually used internally. The different class sets
(externally signalled vs. internally applied one) require an
undisclosed strictly defined mapping at the AS borders between the
two. This way, a distinction between internal and external QoS Class
Sets can be achieved.

The general need for class based accounting is not addressed by this
draft. MIB extensions are also required, which separate traffic
variables by traffic marking. It is expected for both that existing
procedures can be reused in a class based manner.

3. Related Work

A number of QoS improvement approaches have been proposed before and
a selection will be briefly mentioned in this section.

Most of the approaches perform parameter signalling.
[I-D.jacquenet-bgp-qos] defines the QOS_NLRI attribute, which is used
for propagating QoS-related information associated to the NLRI
(Network Layer Reachability Information) information conveyed in a
BGP UPDATE message. Single so called "QoS routes" are signalled,
which fulfil certain QoS requirements. Several information types are
defined for the attribute, which concentrate on rate and delay type
parameters.

[I-D.boucadair-qos-bgp-spec] is based on the specified QOS_NLRI
attribute and introduces some modifications to it. The notion of AS-
local and extended QoS classes is used, which effectively describes
the local set of QoS performance parameters or their cross-domain
combined result. Two groups of QoS delivery services are
distinguished, where the second group concentrates on ID associated
QoS parameter propagation between adjacent peers. The first group is
of more interest for this draft since it concentrates on the
"identifier propagation" such as the DSCP value for example.
However, this signalling is specified for the information exchange
between adjacent peers only and assumes the existence of extended QoS
classes and offline traffic engineering functions.

Another approach is described in [I-D.liang-bgp-qos]. It associates
a list of QoS metrics with each prefix by extending the existing
AS_PATH attribute format. Hop-by-hop metric accumulation is
performed as the AS_PATH gets extended in relaying ASes. Metrics are
generically specified as a list of TLV-style attribute elements. The
metrics such as bandwidth and delay are exemplary mentioned in the
draft.

One contribution specialized in the signalling of Type Of Service
(TOS) values which are in turn directly mapped to DSCP values in
section 3.2 of the draft [I-D.zhang-idr-bgp-extcommunity-qos]. The
TOS value is signalled within an Extended Community Attribute and, if
it is understood correctly, will be applied to a certain route. An
additional value field is used to identify, which routes belong to
which signalled TOS community. Who advertises such attributes and
whether they are of transitive or non-transitive type remains
unspecified.

The most comprehensive analysis (although not an IETF draft) is given
in [MIT_CFP]. This "Inter- provider Quality of Service" white paper
examines the inter-domain QoS requirements and derives a
comprehensive approach for the introduction of at least one QoS class
with guaranteed delay parameters. The implementation aspects of
metering, monitoring, parameter feedback and impairment allocations
are all considered in the white paper. However, QoS guarantees and
parameter signalling is beyond the intention of this QoS Marking
draft.

Other drafts may also be considered as related work as long as they
convey QoS marking information and might be "misused" for QoS class
signalling.

One example is the usage of the "Traffic Engineering Attribute" as
defined in [RFC5543]. However, the attribute is non-transitive and
the LSP encoding types are not generally applicable to inter-domain
interconnection types. Its usage of the targeted QoS Marking
signalling is not possible. The included maximum bandwidth of each
of eight priority classes, could however be used in future draft
extensions.

The second example is the current "Dissemination of flow
specification rules" draft [RFC5575]. It defines a new BGP NLRI
encoding format, which can be used to distribute traffic flow
specifications. Such flow specification can also include DSCP values
as type 11 in the NLRI. Furthermore, one could signal configuration
actions together with the DSCP encoding, which could be used for
filtering purposes or even trigger remarking and route selection with
it. Such usage is not defined in the draft and can hardly be
achieved because of the following reasons. The flow specification is
focused on single flows, which might even be part of an aggregate.
Such fine grained specification is counterproductive for the coarse
grained general QoS Marking approach of this draft. The novel
approach of cross-layer QoS Marking could also not be incorporated,
which might be essential for future tunnelled inter-domain
interconnection.

4. **Definition of the QoS Marking Community**

4.1. **Extended Community Type**

   The new QoS Marking community is encoded in a BGP Extended Community
   Attribute [RFC4360]. It is therefore a transitive optional BGP
   attribute with Type Code 16. An adoption to the simple BGP Community
   Attribute encoding [RFC1997] is not defined in this document. The
   actual encoding within the BGP Extended Community Attribute is as
   follows.

   The QoS Marking community is of regular type which results in a 1
   octet Type field followed by 7 octets for the QoS marking structure.
   The Type is IANA-assignable and marks the community as transitive
   across ASes. The type number has been assigned by IANA to 0x04
   [IANA_EC].

   Optionally, a non-transitive Type value assignment of 0x44 is
   provided, which allows for the AS internal marking information
   exchange. The community format remains untouched for the non-
   transitive version.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 0 0 0|                                               |
+-+-+-+-+-+-+-+-+   7 octet QoS Marking community structure     |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
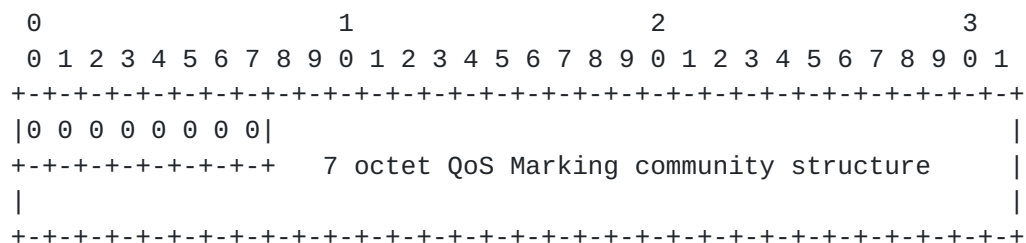
                              Figure 1

4.2. **Structure of the QoS Marking Community**

   The QoS Marking community provides a flexible encoding structure for
   various QoS Markings on different layers. This flexibility is
   achieved by a Flags, a QoS Set Number and a Technology Type field
   within the 7 octet structure as defined below.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Flags      | QoS Set Number|Technology Type| QoS Marking Oh|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| QoS Marking Ol| QoS Marking A |0 0 0 0 0 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
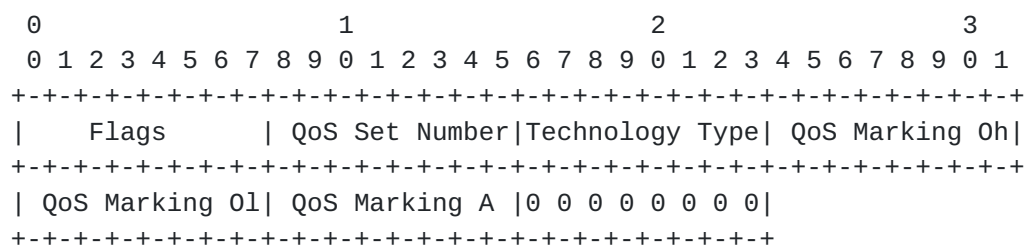
                              Figure 2

Flags:
```
 0  1  2  3  4  5  6  7
+--+--+--+--+--+--+--+--+
|0  0 |P |R |I |A |0 |0 |
+--+--+--+--+--+--+--+--+
```

                                Figure 3

   All used and unused flags default to a value of '0'. The
   following table shows the bit encoding of the Flags field.

```
+-----+--------+-----------------------------------------+
| Bit | Flag   | Encoding                                |
+-----+--------+-----------------------------------------+
| 0-1 | unused | Default to '0'                          |
| 2   | P      | '1' ...  Marking is preserved           |
| 3   | R      | '1' ...  Remarking occurred             |
| 4   | I      | '1' ...  QoS marking ignored            |
| 5   | A      | '1' ...  QoS class aggregation occurred |
| 6,7 | unused | Default to '0'                          |
+-----+--------+-----------------------------------------+
```

                                Table 1

   The 'P' flag indicates the preservation of incoming markings
   during the transit forwarding process. The IP prefix originating
   AS SHOULD set the flag to '1', which is otherwise implied by an
   AS_PATH length of 1 ASN. Transit ASes MUST set the flag to '1',
   if the advertised Marking A is accepted at the ingress and is sent
   out unchanged at the egress. That is, no remarking occurs -
   neither for marking adoption with the neighbouring downstream AS
   nor by resetting the markings. This flag field is set and cleared
   by each relaying AS according to its handling of markings -
   irrespective of the possible ignorance of the particular Marking A
   in the internal per hop forwarding behaviour.

   The Flags "R, I and A" are set to '0' in the advertisement by the
   IP prefix originating AS. Transit ASes MUST change the flag value
   to '1' once the respective event occurred. If the QoS marking
   actively used in the transit AS internal forwarding is different
   from the advertised original one, the 'Remarking (R)' flag is set
   to '1'. This MUST be done separately for each technology type
   community within the community set. The same applies to the
   'Ignore (I)' flag, if the respective advertised QoS marking is
   ignored in the transit AS internal forwarding.

The 'Aggregation (A)' flag MUST be set to '1' by the UPDATE
message relaying transit AS, if the respective IP prefixes will be
advertised inside an IP prefix aggregate constituted from
differing Class Sets.

If the defined "R, I and A" flags are cleared - and by means of
the cleared 'Partial' flag of the BGP attribute it is shown, that
no "QoS Class ignorant" AS is involved in the forwarding path - a
consistent class based overall traffic separated forwarding is
available along this path.

QoS Set Number:

Several single QoS Marking communities can be logically grouped
into a QoS Marking community Set characterized by a identical QoS
Set Number. This grouping of the single QoS Marking communities
into a set provides cross-layer linking between the QoS class
encodings. It can also be used for the specification of behaviour
sets as given in the [RFC3140]. The number of signalled QoS
Marking communities as well as QoS Marking community Sets is at
the operator's choice of the originating AS. The enumerated QoS
set numbers have BGP UPDATE message local significance starting
with set number 0x00.

Technology Type:

The technology type encoding uses the enumeration list in
(Section 4.3). Future version of this draft will need an extended
enumeration list administered by IANA.

QoS Marking / Enumeration O & A:

The interpretation of these fields depends on the selected layer and
technology. ASes, which process the community and support the given
QoS Class by means of a QoS mechanism using bit encodings for the
targeted behaviour (e.g. IP DSCP, Ethernet User Priority, MPLS TC
etc.) MUST use a copy of the encoding in the "QoS Marking A"
community field. Unused higher order bits default to '0'. Other
technologies, which use separate forwarding channels for different
classes (such as L-LSPs, VPI/VCI inferred ATM classes, lambda
inferred priority, etc.) SHALL use class enumerations as encoding in
this community field. The enumeration count starts with zero for the
best effort traffic class and rises by one with each available higher
priority class.

There are two QoS Marking fields within the QoS Marking community for
the "original (O)" and the "active (A)" QoS marking. Higher order
bits of those fields, which are not used for the respective behaviour

encoding, default to zero.

QoS Marking O (Original QoS Marking):

   This field is a 16 bit QoS Marking field, which consists of of a
   high ("Oh") and a low ("Ol") octet. The IP prefix originating AS
   copies the internally associated QoS encoding of the given
   Technology Type into this one octet field. The field value is
   right-aligned depending on the number of encoded bits. For the IP
   technology, the encoding of Per Hop Behaviour Codes has to follow
   the definitions stated in [RFC3140]. The field MUST remain
   unchanged in BGP UPDATE messages of relaying nodes.

QoS Marking A (Active QoS Marking):

   QoS Marking A and O MUST be identically encoded by the prefix
   originating AS, except for the case, where IP technology Per Hop
   Behaviours are addressed. "QoS Marking A" will always contain the
   locally applied encoding for the targeted PHB.

   All other ASes use this Active QoS Marking field to advertise
   their locally applied internal QoS encoding of the given class and
   technology at the interconnection point. The field value is
   right-aligned depending on the number of encoded bits. A cleared
   Marking field (all zero) signals that this traffic class
   experiences default traffic treatment within the transit AS
   forwarding technology.

4.3. Technology Type Enumeration

   A small list of technologies is provided in the table below for the
   direct encoding of common technology types. The mapping of all
   virtual channel technologies into a single technology type value is
   for limiting the number of different communities in an UPDATE
   message. It is therefore a contribution to scalability.

```
+-------+----------------------------------------------------------+
| Value | Technology Type                                          |
+-------+----------------------------------------------------------+
| 0x00  | DiffServ enabled IP (DSCP encoding)                      |
| 0x01  | Ethernet using 802.1q priority tag                       |
| 0x02  | MPLS using E-LSP                                          |
| 0x03  | Virtual Channel (VC) encoding using separate channels for|
|       | QoS forwarding / one channel per class (e.g.  ATM VCs, FR |
|       | VCs, MPLS L-LSPs)                                         |
| 0x04  | GMPLS - time slot encoding                               |
| 0x05  | GMPLS - lambda encoding                                   |
| 0x06  | GMPLS - fibre encoding                                   |
+-------+----------------------------------------------------------+
```

Table 2

5. Community Usage

Providers MAY choose to process the QoS Marking communities and adopt
the behaviour encoding and tunnel selection according to their local
policy. Whether this MAY also lead to different IGP routing
decisions or even effect BGP update filters is out of scope for the
community definition.

Only the IP prefix originating AS is allowed to signal the QoS
Marking communities and Sets. AS providers, which make use of this
signalling mechanism MUST make sure, that only one external Class Set
will be advertised for the AS. All advertised prefixes, which
originate from that AS will be sent with the same QoS Marking
community Set in the respective UPDATE message. Transit ASes MUST
NOT modify or extend the QoS Marking community Set except for the
update of each 'QoS Marking A' field contained in the community Set
and the respective "P, R, I, A" flags. Prefixes with associated
identical QoS Marking community Sets are to be advertised together in
common UPDATE messages in relaying nodes.

Figure 4 shows an AS interconnection example with different Class
Sets. It shows the case in AS 5 where different Class Sets are used
internally and externally. The proposed QoS Class Set signalling
will always use the external definitions within the UPDATE message
QoS Marking communities. The example also shows, that IP prefixes,
which originate in AS 5 and AS 3 can be advertised together with the
same QoS Marking community Set as long as their Layer 2 encoding is
identical.

```
                    AS 5 = Transit AS
   +-----------+     =================     +-----------+
   +   AS 1    +      AS internal:        +   AS 3    +
   + 4 classes +         5 classes        + 3 classes  +
   +   L2/L3   +          L2/L3           +   L2/L3    +
   +(EF,2xAF,BE)+      AS external:        +(EF,AF1,BE)+
   +        [] +        3 classes          +[]         +
   +-----------+         L3 (EF,AF1,BE)   +-----------+
              \    +--------------+    /
               \   |        []        |   /
                \  |      /  \       |  /
                 \ |  --()---()--   | /
                  \| /   |     |   \ |/
                  |[]    |     |   []|
                  /| \   |     |  / |\
                 / |  --()---()--  | \
                /  |    \  /       |  \
               /   |       []       |   \
              /    +--------------+    \
   +-----------+                    +-----------+
   +        [] +                    +[]         +
   +   AS 2    +                    +   AS 4    +
   + 2 classes +                    + 6 classes  +
   +   L2/L3   +                    +  L1/L2/L3 +
   +  (EF,BE)  +                    +(EF,4xAF,BE)+
   +-----------+                    +-----------+
   [] ... AS Border Router
   () ... AS internal Router
```
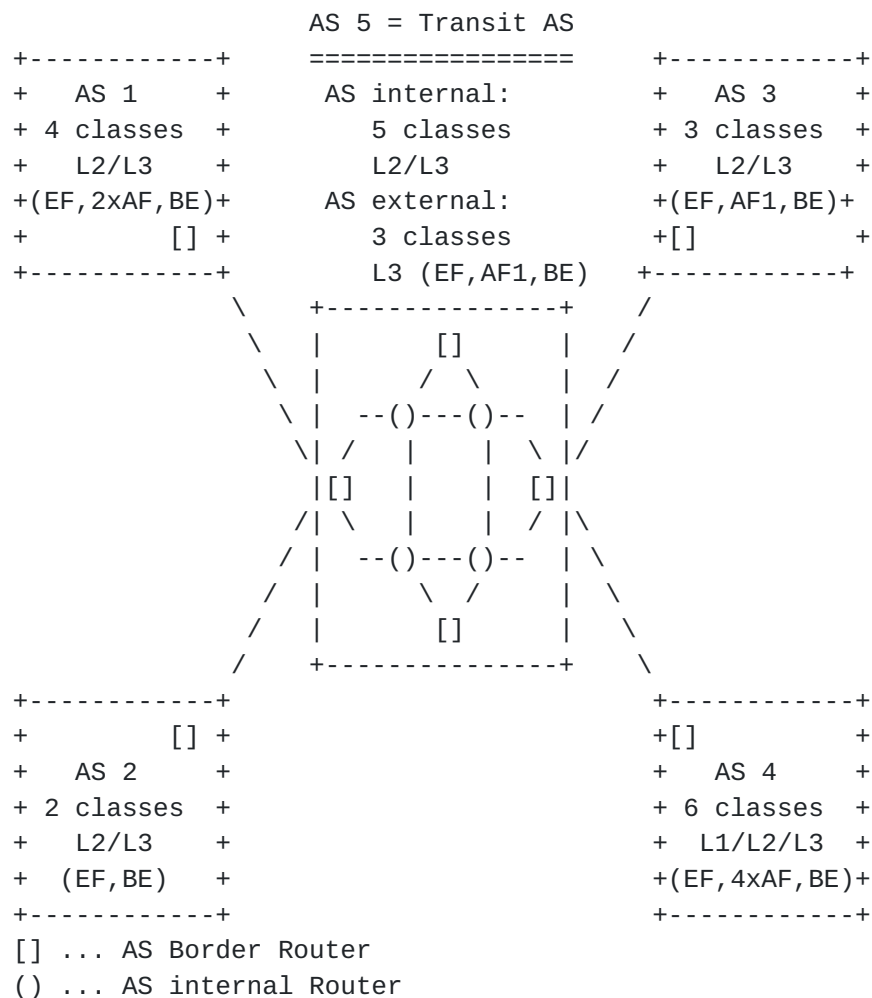
Figure 4

5.1. QoS Marking Example

See Appendix A for an example QoS Marking community Set.

5.2. AS Border Packet Forwarding

   IP packet forwarding based on packet header QoS encoding might
   require remarking of packets in order to match AS internal policies
   and encodings of neighbouring ASes.

   Identical QoS class sets and encodings between neighbouring ASes do
   not require any remarking. Different encodings will be matched on
   the outgoing traffic.

   Outgoing traffic for a given IP prefix uses the 'QoS Marking A'
   information of the respective BGP UPDATE message QoS Marking
   community for adopted remarking of the forwarded packet.

If the 'I' flag is set for a given encoding, the outgoing traffic
remarking SHOULD still be applied despite of the signalled lack of
QoS Class forwarding support. This is particularly important, if the
preserve flag 'P' is signalled together with the 'I' flag.

5.3. IP Prefix Aggregation

Several IP prefixes of different IP prefix originating ASes MAY be
aggregated to a shorter IP prefix in transit ASes. If the original
Class Sets of the aggregated prefixes are identical, the aggregate
will use the same Set. In all other cases, the resulting IP prefix
aggregate is handled the same as if the transit AS were the
originating AS for this aggregated prefix. The transit AS provider
MAY care for AS internal mechanisms, which map the signalled
aggregate QoS Class Set to the different original Class Sets in the
internal forwarding path.

In case of IP prefix aggregation with different QoS Class Sets, the
'Aggregation (A)' flag of each QoS Marking community within the Set
MUST be set to '1'.

6. Confidentiality Considerations

The disclosure of confidential AS intrinsic information is of no
concern since the signalled marking for QoS class encodings can be
adopted prior to the UPDATE advertisement of the IP prefix
originating AS. This way, a distinction between internal and
external QoS Class Sets can be achieved. AS internal cross-layer
marking adaptation and policy based update filtering allows for
consistent QoS class support despite made up QoS Class Set and
encoding information within UPDATE advertisements. In case of such
policy hiding strategy, the required AS internal ingress and egress
adaptation SHALL be done transparently without explicit "Active
Marking" and 'R' flag signalling.

7. IANA Considerations

This document defines a new BGP Extended Community, which includes a
"Technology Type" field. Section 4.3 enumerates a number of popular
technologies. This list is expected to suffice for first
implementations. However, future or currently uncovered technologies
may arise, which will require an extended "Technology Type"
enumeration list administered by IANA.

A new extended community QoS Marking community is defined, which has
been assigned a Type value of 0x04 for a transitive and 0x44 for a

non-transitive usage.

8. Security Considerations

This extension to BGP does not change the underlying security issues inherent in the existing BGP.

Malicious signalling behaviour of QoS Marking community advertising ASes can result in misguided neighbours about non existing or maliciously encoded Class Sets. Removal of QoS Marking community Sets leads to the current best effort interconnection, which is no stringent security concern.

The IP prefix originating AS MAY place a copy of its marking information into the Internet Routing Registry (IRR) for global reference.

The strongest threat is the advertisement of numerous very fine grained Class Sets, which could limit the scalability of this approach. However, neighbouring ASes are free to set the ignore flag of single communities or to stop processing the QoS Marking communities of a certain routing advertisement, once a self-set threshold has been crossed. By means of this self defence mechanism it should not be possible to crash neighbouring peers due to the excessive use of the new community.

9. References

9.1. Normative References

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Appendix A. QoS Marking Example

   The example AS is advertising several IP prefixes, which experience

equal QoS treatment from AS internal networks. The IP packet
forwarding policy within this originating AS defines e.g. 3 traffic
classes for IP traffic (DSCP1, DSCP2 and DSCP3). These three classes
are also consistently taken care of within a TC bit supporting MPLS
tunnel forwarding. The BGP UPDATE message for the announced IP
prefixes will contain the following QoS Marking community Set
together with the IP prefix NLRI.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 1 0 0 0 0 0|0 0 0 0 0 0 0 0|0 0 0 0 0 0 0 0|1 0 1 1 1 0 0 0|
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|0 0 0 0 0 0 0 0|0 0 1 0 1 1 1 0|0 0 0 0 0 0 0 0|
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|0 0 1 0 0 0 0 0|0 0 0 0 0 0 0 0|0 0 0 0 0 0 1 0|0 0 0 0 0 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 1 0 1|0 0 0 0 0 1 0 1|0 0 0 0 0 0 0 0|
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|0 0 1 0 0 0 0 0|0 0 0 0 0 0 0 1|0 0 0 0 0 0 0 0|0 0 1 0 1 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 0 1 0|0 0 0 0 1 0 1 0|0 0 0 0 0 0 0 0|
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|0 0 1 0 0 0 0 0|0 0 0 0 0 0 0 1|0 0 0 0 0 0 1 0|0 0 0 0 0 0 0 0|
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|0 0 0 0 0 0 0 1|0 0 0 0 0 0 0 1|0 0 0 0 0 0 0 0|
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|0 0 1 0 0 0 0 0|0 0 0 0 0 0 1 0|0 0 0 0 0 0 0 0|0 1 0 0 1 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 0 1 0|0 0 0 1 0 0 1 0|0 0 0 0 0 0 0 0|
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|0 0 1 0 0 0 0 0|0 0 0 0 0 0 1 0|0 0 0 0 0 0 1 0|0 0 0 0 0 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0 0 0 0 0 0 1 0|0 0 0 0 0 0 1 0|0 0 0 0 0 0 0 0|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The class set as well as the example encodings are arbitrarily chosen.

Figure 5

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