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Advertisement of Multiple Paths in BGP  
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## Abstract

This document defines a BGP extension that allows the advertisement of multiple paths for the same address prefix without the new paths implicitly replacing any previous ones. The essence of the extension is that each path is identified by a path identifier in addition to the address prefix.

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Internet-Draft

ADD-PATH

November 2015

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## Table of Contents

<a href="#">1.</a>	Introduction . . . . .	<a href="#">2</a>
<a href="#">1.1.</a>	Specification of Requirements . . . . .	<a href="#">2</a>
<a href="#">2.</a>	How to Identify a Path . . . . .	<a href="#">3</a>
<a href="#">3.</a>	Extended NLRI Encodings . . . . .	<a href="#">3</a>
<a href="#">4.</a>	ADD-PATH Capability . . . . .	<a href="#">3</a>
<a href="#">5.</a>	Operation . . . . .	<a href="#">4</a>
<a href="#">6.</a>	Applications . . . . .	<a href="#">5</a>
<a href="#">7.</a>	Deployment Considerations . . . . .	<a href="#">5</a>
<a href="#">8.</a>	IANA Considerations . . . . .	<a href="#">6</a>
<a href="#">9.</a>	Security Considerations . . . . .	<a href="#">6</a>
<a href="#">10.</a>	Acknowledgments . . . . .	<a href="#">6</a>
<a href="#">11.</a>	References . . . . .	<a href="#">6</a>
<a href="#">11.1.</a>	Normative References . . . . .	<a href="#">6</a>
<a href="#">11.2.</a>	Informative References . . . . .	<a href="#">7</a>
	Authors' Addresses . . . . .	<a href="#">7</a>

## [1.](#) Introduction

The BGP specification [[RFC4271](#)] defines an Update-Send Process to advertise the routes chosen by the Decision Process to other BGP speakers. No provisions are made to allow the advertisement of multiple paths for the same address prefix, or Network Layer Reachability Information (NLRI). In fact, a route with the same NLRI as a previously advertised route implicitly replaces the previous advertisement.

This document defines a BGP extension that allows the advertisement of multiple paths for the same address prefix without the new paths implicitly replacing any previous ones. The essence of the extension is that each path is identified by a path identifier in addition to the address prefix.

### [1.1.](#) Specification of Requirements

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 [[RFC2119](#)].

## [2.](#) How to Identify a Path

As defined in [[RFC4271](#)], a path refers to the information reported in the path attribute field of an UPDATE message. As the procedures specified in [[RFC4271](#)] allow only the advertisement of one path for a particular address prefix, a path for an address prefix from a BGP peer can be keyed on the address prefix.

In order for a BGP speaker to advertise multiple paths for the same address prefix, a new identifier (termed "Path Identifier" hereafter) needs to be introduced so that a particular path for an address prefix can be identified by the combination of the address prefix and the Path Identifier.

The assignment of the Path Identifier for a path by a BGP speaker is purely a local matter. However, the Path Identifier MUST be assigned in such a way that the BGP speaker is able to use the (prefix, path identifier) to uniquely identify a path advertised to a neighbor. A BGP speaker that re-advertises a route MUST generate its own Path Identifier to be associated with the re-advertised route. A BGP speaker that receives a route SHOULD NOT assume that the identifier carries any particular semantics; it SHOULD be treated as an opaque value.

## [3.](#) Extended NLRI Encodings

In order to carry the Path Identifier in an UPDATE message, the NLRI encoding MUST be extended by prepending the Path Identifier field, which is of four-octets.

For example, the NLRI encoding specified in [[RFC4271](#)] is extended as the following:

```
+-----+
| Path Identifier (4 octets) |
+-----+
```

```

| Length (1 octet) |
+-----+
| Prefix (variable) |
+-----+

```

The usage of the extended NLRI encodings is specified in [Section 5](#).

#### 4. ADD-PATH Capability

The ADD-PATH Capability is a new BGP capability [[RFC5492](#)]. The Capability Code for this capability is specified in the IANA Considerations section of this document. The Capability Length field

of this capability is variable. The Capability Value field consists of one or more of the following tuples:

```

+-----+
| Address Family Identifier (2 octets) |
+-----+
| Subsequent Address Family Identifier (1 octet) |
+-----+
| Send/Receive (1 octet) |
+-----+

```

The meaning and use of the fields are as follows:

Address Family Identifier (AFI):

This field is the same as the one used in [[RFC4760](#)].

Subsequent Address Family Identifier (SAFI):

This field is the same as the one used in [[RFC4760](#)].

Send/Receive:

This field indicates whether the sender is (a) able to receive multiple paths from its peer (value 1), (b) able to send multiple paths to its peer (value 2), or (c) both (value 3) for the <AFI, SAFI>.

If any other value is received, then the capability SHOULD be

treated as not understood and ignored [[RFC5492](#)].

## 5. Operation

The Path Identifier specified in the previous section can be used to advertise multiple paths for the same address prefix without subsequent advertisements replacing the previous ones. Apart from the fact that this is now possible, the route advertisement rules of [[RFC4271](#)] are not changed. In particular, a new advertisement for a given address prefix and a given path identifier replaces a previous advertisement for the same address prefix and path identifier. If a BGP speaker receives a message to withdraw a prefix with a path identifier not seen before, it SHOULD silently ignore it.

For a BGP speaker to be able to send multiple paths to its peer, that BGP speaker MUST advertise the ADD-PATH capability with the Send/Receive field set to either 2 or 3, and MUST receive from its peer the ADD-PATH capability with the Send/Receive field set to either 1 or 3, for the corresponding <AFI, SAFI>.

A BGP speaker MUST follow the procedures defined in [[RFC4271](#)] when generating an UPDATE message for a particular <AFI, SAFI> to a peer unless the BGP speaker advertises the ADD-PATH Capability to the peer indicating its ability to send multiple paths for the <AFI, SAFI>, and also receives the ADD-PATH Capability from the peer indicating its ability to receive multiple paths for the <AFI, SAFI>, in which case the speaker MUST generate a route update for the <AFI, SAFI> based on the combination of the address prefix and the Path Identifier, and use the extended NLRI encodings specified in this document. The peer SHALL act accordingly in processing an UPDATE message related to a particular <AFI, SAFI>.

A BGP speaker SHOULD include the bestpath when more than one path are advertised to a neighbor unless the bestpath is a path received from that neighbor.

As the Path Identifiers are locally assigned, and may or may not be persistent across a control plane restart of a BGP speaker, an implementation SHOULD take special care so that the underlying forwarding plane of a "Receiving Speaker" as described in [[RFC4724](#)] is not affected during the graceful restart of a BGP session.

## [6.](#) Applications

The BGP extension specified in this document can be used by a BGP speaker to advertise multiple paths in certain applications. The availability of the additional paths can help reduce or eliminate persistent route oscillations [[RFC3345](#)]. It can also help with optimal routing and routing convergence in a network. The applications are detailed in separate documents.

## [7.](#) Deployment Considerations

The extension proposed in this document provides a mechanism for a BGP speaker to advertise multiple paths over a BGP session. Care needs to be taken in its deployment to ensure consistent routing and forwarding in a network, the details of which will be described in separate application documents.

When deployed as a provider edge router or a peering router that interacts with external neighbors, a BGP speaker usually advertises at most one path to the internal neighbors in a network. In the case the speaker is configured to advertise multiple paths to the internal neighbors, and additional information is needed for the application, the speaker could use attributes such as the Edge\_Discriminator attribute [[I-D.pmohapat-idr-fast-conn-restore](#)]. The use of that type of additional information is outside the scope of this document.

## [8.](#) IANA Considerations

IANA has assigned capability number 69 for the ADD-PATH Capability described in this document. This registration is in the BGP Capability Codes registry.

## [9.](#) Security Considerations

This document defines a BGP extension that allows the advertisement of multiple paths for the same address prefix without the new paths implicitly replacing any previous ones. As a result, multiple paths for a large number of prefixes may be received by a BGP speaker potentially depleting memory resources or even causing network-wide instability. The use of the ADD-PATH Capability is intended to address specific needs related to, for example, eliminating the MED-

induced route oscillations in a network [[I-D.ietf-idr-route-oscillation-stop](#)]. While the applications for the ADD-PATH Capability are outside the scope of this document, the users are encouraged to examine their behavior and potential impact by studying the best practices described in [[I-D.ietf-idr-add-paths-guidelines](#)].

This document introduces no new security concerns in the base operation of BGP [[RFC4271](#)].

## [10.](#) Acknowledgments

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