Doing Don’ts: Modifying BGP Attributes within an Autonomous System

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The Point of View of an AS

- **eBGP peerings** to exchange information on interdomain routing

- **iBGP peerings** to distribute eBGP routes within an AS

- Route Reflector hierarchy, to scale iBGP
About The Role of iBGP

- iBGP just propagates eBGP routes across the AS
- Typically, no policy is applied in iBGP
  - Policies are applied only at the border
  - Best practices do not recommend applying policies in iBGP
  - Research community often assumes that iBGP messages are left untouched ([Griffin02],[Flavel08])
Our Contributions: Doing Don’ts

- Consequences of changing iBGP messages are poorly understood
- We investigate pros and cons
  - why an ISP should (not) modify iBGP messages?
  - who currently change iBGP attributes in the real world?
  - what are the consequences on iBGP stability?
    - technique and tool for detecting instabilities
  - how can an ISP change iBGP attributes without affecting iBGP stability?
    - configuration guidelines
Why Should an AS Change iBGP attributes?

• attributes influence the *BGP decision process*

<table>
<thead>
<tr>
<th>Step</th>
<th>Criterion</th>
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<tbody>
<tr>
<td>1</td>
<td>Prefer routes with higher LOCAL-PREFERENCE</td>
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<tr>
<td>2</td>
<td>Prefer routes with lower AS-PATH length</td>
</tr>
<tr>
<td>3</td>
<td>Prefer routes with lower ORIGIN</td>
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• An ISP can change iBGP attributes as an additional knob to better engineer its traffic
  ▫ recent Cisco IOS releases allow operators to partially modify the decision process
Simple Scenario

eBGP announcement
AS-PATH **ABCD**

US

EU

eBGP announcement
AS-PATH **YZD**

PAIX

AMS-IX

BR1

BR2

RR1

RR2
Simple Scenario

- **eBGP announcement**
  - AS-PATH **ABCD**

- **iBGP attributes are not changed by any router**

- **all the traffic to AS D exits from BR2**
Simple Scenario

eBGP announcement
AS-PATH ABCD

if msg from BR1:
set local-pref 120

if msg from BR2:
set local-pref 120

AMS-IX

BR1

BR2

RR1

RR2
Who engineers iBGP in real world?

```
route-server.phx1>sh ip bgp 189.90.12.0/24
Paths: (4 available, best #1)
13878 15180 28189 28189 28189 28189 (received & used)
67.17.64.89 from 67.17.80.210 (67.17.80.210)
 Origin IGP, metric 0, localpref 300, valid, internal, best
 Community: 3549:4471 3549:30840
 Originator: 67.17.81.221, Cluster list: 0.0.0.92
...
28189 28189 28189 28189 28189 28189 28189 28189, (received & used)
67.17.64.89 from 67.17.82.40 (67.17.82.40)
 Origin IGP, metric 0, localpref 300, valid, internal
 Community: 3549:4950 3549:34076
 Originator: 200.186.0.67, Cluster list: 0.0.2.109, 0.0.5.2
```
iBGP Attribute Changing in Internet

• We estimated the number of ASes which exhibit simultaneously active routes having different AS-PATH length
  ▫ conservative approach
  ▫ dataset: RIBs from RIS and Routeviews (May 2009)
• We found that 1,838 ASes out of 32,066 (5.7%) change iBGP attributes
What Impact on Routing Stability?

- We use a custom extension of the Stable Path Problem (SPP) framework as the model
  - an undirected graph represents (i)BGP peerings

![Diagram](image)

- eBGP paths are collapsed in single edges
- Each node ranks permitted paths to reach the destination prefix
More Flexibility = More Instability

- **Theo**: BGP configurations that allow iBGP attribute changing can generate a larger set of oscillations than BGP configurations where iBGP attributes are not modified.

```
if msg from b2: set local-pref 120
if msg from b1: set local-pref 120
```
Detecting Oscillations

- We propose a technique to automatically check iBGP configuration for routing stability
  - Known detection techniques assume that iBGP attributes are left unchanged [Flavel08]
  - Conveniently translating an iBGP configuration into an SPP instance allows us to check for stability even when iBGP attributes are changed
  - The SPP instance is then checked with a known polynomial heuristic algorithm [Cittadini08]
A Stability Checker Tool

- We built and evaluated a prototype tool able to check iBGP configurations for stability
Evaluation of the Tool

• We evaluated the stability checker on both synthetic and real-world configurations
  • in-vitro configurations with up to 1100 iBGP speaking routers
    • three route reflection levels
    • 20 eBGP routes injected
  • real-world configuration of a medium-sized Italian ISP for all the prefixes in the full RIB
    • the entire test takes only few minutes
Performance of the Tool
How Can We Prevent Oscillations?

• The more flexibility comes at the cost of increased instability
  ▫ Is it possible to profitably change iBGP attributes without affecting routing stability and requiring low additional management complexity?

• We provide some configuration guidelines
  ▫ two main high-level requirements
    • routers should be ranked according to revenues and costs [GaoRexford00]
    • internal transit cost should be minimized
Configuration Guidelines

**Guideline A.** Every iBGP speaker assigns to each route a local-preference value such that
- \( \text{LP}_{\text{cust}} > \text{LP}_{\text{peer}} > \text{LP}_{\text{prov}} \)

**Guideline B.** Route reflectors prefer the routes propagated from their own clients
- \( \text{LP}_{\text{cust-client}} > \text{LP}_{\text{cust-non-client}} > \text{LP}_{\text{peer-client}} > \text{LP}_{\text{peer-non-client}} \)

We also formally proved that these guidelines guarantee routing stability
Conclusions

- We explored the possibility of changing attributes in iBGP, evaluating pros

<table>
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<tr>
<th>Pro</th>
<th>Aspect</th>
<th>Contributions</th>
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<tr>
<td></td>
<td>Better traffic engineering</td>
<td>We showed a simple scenario in which an ISP is allowed to easily perform fine-grained TE</td>
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<td></td>
<td>Complete control of traffic flow</td>
<td>We showed that iBGP attribute changing can prevent traffic shift and modification of load balancing</td>
</tr>
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<td>Added flexibility</td>
<td>We showed that some real-world ASes already change iBGP attributes</td>
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Conclusions

• We explored the possibility of changing attributes in iBGP, evaluating pros and cons

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<td>Con</td>
<td>Stability Problem is exacerbated</td>
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<tr>
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<td>• We defined configuration guidelines which ensure stability</td>
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<td>• We proposed a technique for detecting routing instabilities</td>
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<td>• We realized a prototype tool able to efficiently detect instabilities</td>
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<tr>
<td>Con</td>
<td>Management complexity</td>
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<td>Our guidelines do not add significant configuration complexity</td>
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