A Distributed Method for Dynamic Resolution of BGP Oscillations

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1 BGP presentation

2 Oscillation problem
   - SPP (Stable Paths Problem)
   - Dispute digraph

3 Our solution
   - Maintaining path local stateful information (PLSI)
   - Token principles
   - Coherence between routing policies

4 Conclusion
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4 Conclusion
Autonomous System (AS) is a set of machines managed by unique administration. Each AS chooses its own internal routing (RIP, OSPF, ...). BGP used for external routing allows each AS to define its own routing policy. Oscillations are due to incoherences between policies.
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3. **Our solution**
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4. **Conclusion**
SPP (Stable Paths Problem) (Griffin & Wilfong [1, 2])

- Each node represents an AS and each edge represents a BGP link.
- AS defines a list of paths ordered by preference related to its own policy.

![Dispute digraph diagram](image)
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![Graph diagram]
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![Diagram of SPP]
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Dispute digraph

- Each node represents a path.
- Dotted lines represent transmission arcs.
- Full lines represent dispute arcs.
Dispute digraph

Theorem

If the dispute digraph related to an instance $S$ of SPP is acyclic, then $S$ contains a stable solution.
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Our solution:

- allows to detect oscillation due to cycles in the dispute digraph.
- marks barred one path in the cycle, in order to break it.
We need only local information to detect an oscillation and thus we respect private policy choices as imposed by BGP.

- Each AS manages **locally** states (+ or -) of its paths.

  ![Diagram showing state transitions](image)

- If an AS detects a state change from state + to state - on one of its paths then it concludes that this path oscillates.
Maintaining path local stateful information (PLSI)

<table>
<thead>
<tr>
<th>step</th>
<th>AS1</th>
<th>AS2</th>
<th>AS3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>rib-in</td>
<td>rib-in</td>
<td>rib-in</td>
</tr>
<tr>
<td>1</td>
<td>*</td>
<td>*</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>*</td>
<td>*</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>*</td>
<td>*</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>*</td>
<td>130</td>
</tr>
<tr>
<td>5</td>
<td>+</td>
<td>*</td>
<td>130</td>
</tr>
<tr>
<td>6</td>
<td>+</td>
<td>*</td>
<td>130</td>
</tr>
<tr>
<td>7</td>
<td>-</td>
<td>*</td>
<td>10</td>
</tr>
</tbody>
</table>

**rib-in**: current path
Two important questions:

- When a path oscillates, how can we know that it belongs to a cycle in the dispute digraph?
- When an oscillation occurs, all paths belonging to the cycle will oscillate. Which path should we mark barred?
Detection of cycle:

1. When an AS detects an oscillation on path $X$, it generates a token $jX$ and joins it with its new BGP announce.
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2. After reception of this message, if an AS has to adopt a new path, it forwards the token $jX$ with the announce of its new path.
Token principles

Detection of cycle:

1. When an AS detects an oscillation on path $X$, it generates a token $jX$ and joins it with its new BGP announce.

2. After reception of this message, if an AS has to adopt a new path, it forwards the token $jX$ with the announce of its new path.

3. If the generator of $jX$ retrieves its token and has to adopt path $X$, it concludes that $X$ belongs to a cycle and marks $X$ barred.
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3. If the generator of $jX$ retrieves its token and has to adopt path $X$, it concludes that $X$ belongs to a cycle and marks $X$ barred.

Please note that the value $jX$ can be assigned with a hashtable, in order to respect confidentiality.
Only one path should be marked barred:

- All ASes having a path belonging to a cycle will retrieve their tokens.
- It is required to define a total order relation on tokens in order to mark barred only one path.
- When an AS receives a token, it checks if this token has a higher priority than its own token. If yes, it forwards this token, otherwise it ignores it.
Token principles

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Definition of relation $<_{\alpha}$

**locally**: Let $A$ be an AS; $\forall$ $P, Q$ paths of $A$, if $P$ is preferred to $Q$ then $P <_{\alpha} Q$.

**globally**: $\forall$ $P, Q$ paths belonging to two different ASes, if $P$ is a sub-path of $Q$ then $P <_{\alpha} Q$. 
Coherence between routing policies

The local relation respects private policy of each AS,

the global relation maintains the coherence between policies of different ASes.
In fact, whatever the policy, a sub-path of any path is obviously better than the whole path.
Coherence between routing policies

Theorem

If $<_{\alpha}$ is a strict order relation then the policies are coherent between themselves.
Coherence between routing policies

New dispute digraph

130 $\lessdot_\alpha$ 10 $\lessdot_\alpha$ 210 $\lessdot_\alpha$ 20 $\lessdot_\alpha$ 320 $\lessdot_\alpha$ 30 $\lessdot_\alpha$ 130

local    global    local    global    local    global

130

10

210

20

320

30

130 320 210
30  20  10
1
3 2
0

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Summary:

1. Detection and resolution of oscillations
   - Dynamic and distributed method
   - Maintaining path local stateful information (PLSI)
   - Tokens are added to BGP messages

2. Coherence between routing policies
Perspectives:

- We adapted our solution in order to take into account failures or appearances of links
- We must check our solution on a simulator
- Manage Byzantine behaviors
- Manage the connectivity problem in BGP


Selma Yilmaz and Ibrahim Matta, *A Randomized Solution to BGP Divergence*, in Proc. of the 2nd IASTED Int. Conf. on Communication and Computer Networks (CCN’04).