Bootstrapping evolvability for inter-domain routing with D-BGP

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This talk in one slide

Q

What **evolvability features** needed in any inter-domain protocol?

A

Pass-through support

Multi-protocol structure

D-BGP (BGP w/features): rich, evolvable Internet
The inter-domain routing infrastructure

Allows access to Internet’s content (e.g., Gmail)

Today, composed of a single protocol, BGP
BGP has many well-known issues

<table>
<thead>
<tr>
<th>Cannot limit ingress traffic</th>
<th>High convergence times</th>
</tr>
</thead>
<tbody>
<tr>
<td>No QoS</td>
<td>Only one best path</td>
</tr>
<tr>
<td>ASes can be spoofed</td>
<td></td>
</tr>
</tbody>
</table>

**Proposed solutions**

<table>
<thead>
<tr>
<th>Proposed solution</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Wiser</td>
<td>[NSDI’07]</td>
</tr>
<tr>
<td>SCION</td>
<td>[SP’11]</td>
</tr>
<tr>
<td>NIRA</td>
<td>[CCR’03]</td>
</tr>
<tr>
<td>HLP</td>
<td>[SIGCOMM’05]</td>
</tr>
<tr>
<td>R-BGP</td>
<td>[NSDI’07]</td>
</tr>
<tr>
<td>MIRO</td>
<td>[SIGCOMM’06]</td>
</tr>
<tr>
<td>Arrow</td>
<td>[SIGCOMM’14]</td>
</tr>
<tr>
<td>BGPSec</td>
<td>[IETFv8]</td>
</tr>
<tr>
<td>Pathlets</td>
<td>[SIGCOMM’09]</td>
</tr>
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<td>EQ-BGP</td>
<td>[AINA’06]</td>
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</table>
BGP has many well-known issues

Cannot limit ingress traffic  High convergence times

No QoS  Only one best path

ASes can be spoofed

BGP is rigid: requires neighbors to use it
Rigidity results in isolated islands

AS supports new protocol  AS supports BGP

Isolation dis-incentivizes deployment
Skirting rigidity with data-plane tunnels

AS supports new protocol

AS supports BGP

Incentivizes non-deployers to fight evolution
Key contributions

The two modest evolvability features
- Pass-through support
- Multi-protocol structure

Makes data-plane tunneling optional

D-BGP, which is not far from BGP
- Only Required 900 lines of code
- BGP already includes pass-through support

Characterization of D-BGP’s benefits
- Enables a rich Internet w/many protocols
- Incentivizes adoption by accelerating benefits
How we identified evolvability features

- R-BGP [NSDI’07]
- SCION [SP’11]
- BGPSec [IETFv8]
- Wiser [NSDI’07]
- MIRO [SIGCOMM’06]
- Pathlet Routing [SIGCOMM’09]

Evolvable Internet

BGP ➞ mod. BGP
Reqs

BGP // Services
Reqs

Global reqs

BGP ➞ FIA
Reqs

Pass-through support (provided by BGP)

Multi-protocol structure
An evolvable Internet

Runs many routing protocols

All ASes support a shared baseline (B)
## Taxonomy of evolvability scenarios

<table>
<thead>
<tr>
<th>Properties</th>
<th>BGP $\rightarrow$ mod. BGP</th>
<th>BGP $\rightarrow$ FIA</th>
</tr>
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<tbody>
<tr>
<td>Extra ctrl info</td>
<td>Extra ctrl info</td>
<td>Different ctrl info</td>
</tr>
<tr>
<td>Wiser, R-BGP</td>
<td>Wiser, R-BGP</td>
<td></td>
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<th>Ex.</th>
<th>BGP $\rightarrow$ mod. BGP</th>
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<th>Deployers</th>
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<th>Non deployers</th>
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<td>Future profits</td>
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<th>Reqs</th>
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<td>Send in-band</td>
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<th>Send across gulfs</th>
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</table>

| Enable discovery | |
|------------------|
Evolvability scenarios (FIA)

Properties


Ex.

SCION, HLP, Pathlets

Incentives

Deployers

Non deployers

Reqs

Send across gulfs

Send in-band

Different ctrl info

E.g., extra paths or link states

Inc. benefits

Joint control

BGP → FIA
Deploying SCION, a FIA protocol

Baseline advertisement
Packet hdr (IP + SCION)
Deploying SCION, a FIA protocol
Deploying SCION, a FIA protocol

Baseline advertisement

Packet hdr (IP + SCION)
Global reqs for an evolvable Internet

Inform islands about protocols on paths

Provide common denominator for e-e paths
Features

Pass-through support

Multi-protocol data structure

Requirements

Disseminate across gulfs

Disseminate in-band

Enable discovery

Inform islands about protocols on paths

Provide common denominator for e-e paths
Outline

Evolvability features

D-BGP design

D-BGP eval
D-BGP overview

BGP advs with Multi-protocol structure

Integrated advs (IAs)

BGP processing with IA support & pass-through

IA processing

Island

Island
D-BGP’s integrated advertisements

**Dest. address:** 128.2.42.52/24

**Path vector**

\[ \text{AS #} \quad \text{Island ID} \quad \rightarrow \quad \text{Abstracts within-island paths} \]

Prevents ASes from discounting end-to-end paths that include within-island paths.
An IA for a path

Dest. address: 128.2.42.52/24

Path vector

<table>
<thead>
<tr>
<th>AS #</th>
<th>Island ID</th>
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<tbody>
<tr>
<td>8</td>
<td>G</td>
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Island ID: G

Island ID: R

Dest.
An IA for a path

**Dest. address:** 128.2.42.52/24

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<th>Path vector</th>
<th>Island desc.</th>
<th>Proto desc.</th>
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<tr>
<td>AS #: 8</td>
<td>Island ID: 8</td>
<td>D-BGP</td>
</tr>
<tr>
<td>Proto(s):</td>
<td>Fields</td>
<td>Origin</td>
</tr>
<tr>
<td>Value(s):</td>
<td></td>
<td>Next hop</td>
</tr>
</tbody>
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**Dest.**

**SCION**

**HLP**

**D-BGP**
Outline

- Evolvability features
- D-BGP design
- D-BGP eval
  - Accelerating benefits
  - Control-plane overhead
  - Quagga implementation
  - New-protocol deployments
Accelerating benefits evaluation
Compared deployment in an Internet with:

- D-BGP
- BGP

Explored benefits as function of adoption
E.g., # paths to dests at upgraded edge domains

Experiments done in simulation
Used Brite [Mascots’01] to generate 1,000-node topology
Used modified routing simulator [SIGCOMM’14]
D-BGP accelerates benefits for SCION

Avg. # of paths to all dests advertised to SCION sources

Fraction of ASes running SCION

1.84x extra paths

D-BGP baseline
BGP baseline
Summary

- BGP’s rigidity $\Rightarrow$ Evolvability
- Two features sufficient for evolvability
- D-BGP provides large evolvability benefits