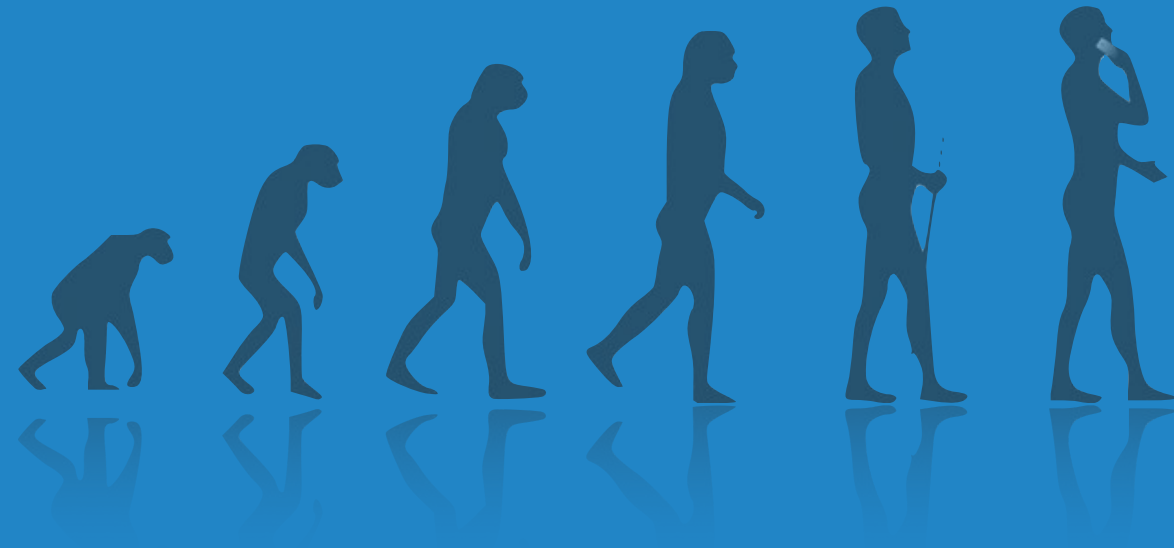# Bootstrapping evolvability for inter-domain routing with D-BGP

Raja Sambasivan

David Tran-Lam, Aditya Akella, Peter Steenkiste

This talk in one slide

Q

What evolvability features needed in any inter-domain protocol?

Existing protocol

New Protocol 1

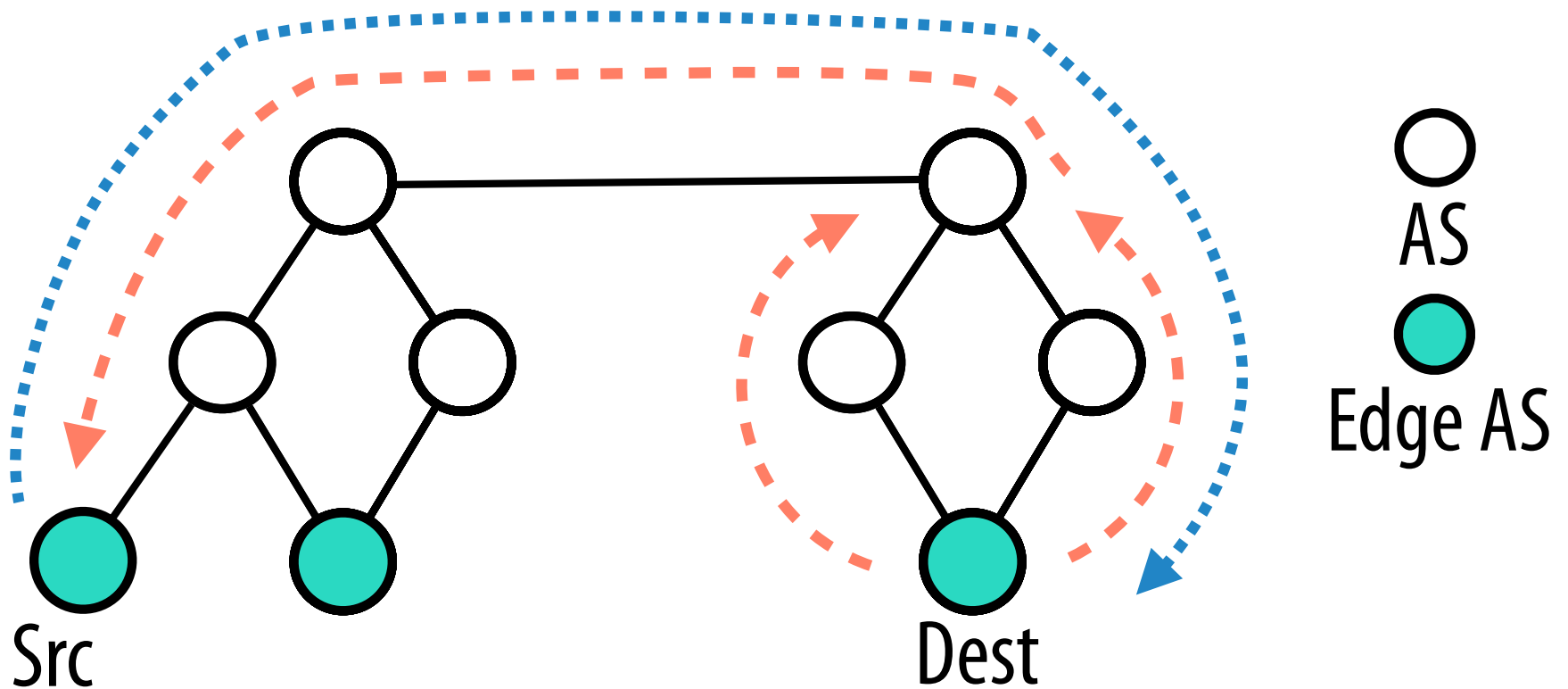New protocol 2

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

Cannot limit ingress traffic   High convergence times

No QoS   Only one best path

ASes can be spoofed
⋮

Proposed solutions

Wiser [NSDI'07]   R-BGP [NSDI'07]   BGPSec [IETFv8]
SCION [SP'11]   MIRO [SIGCOMM'06]   Pathlets [SIGCOMM'09]
NIRA [CCR'03]   Arrow [SIGCOMM'14]   EQ-BGP [AINA'06]
HLP [SIGCOMM'05]   ⋮

BGP has many well-known issues

Cannot limit ingress traffic   High convergence times

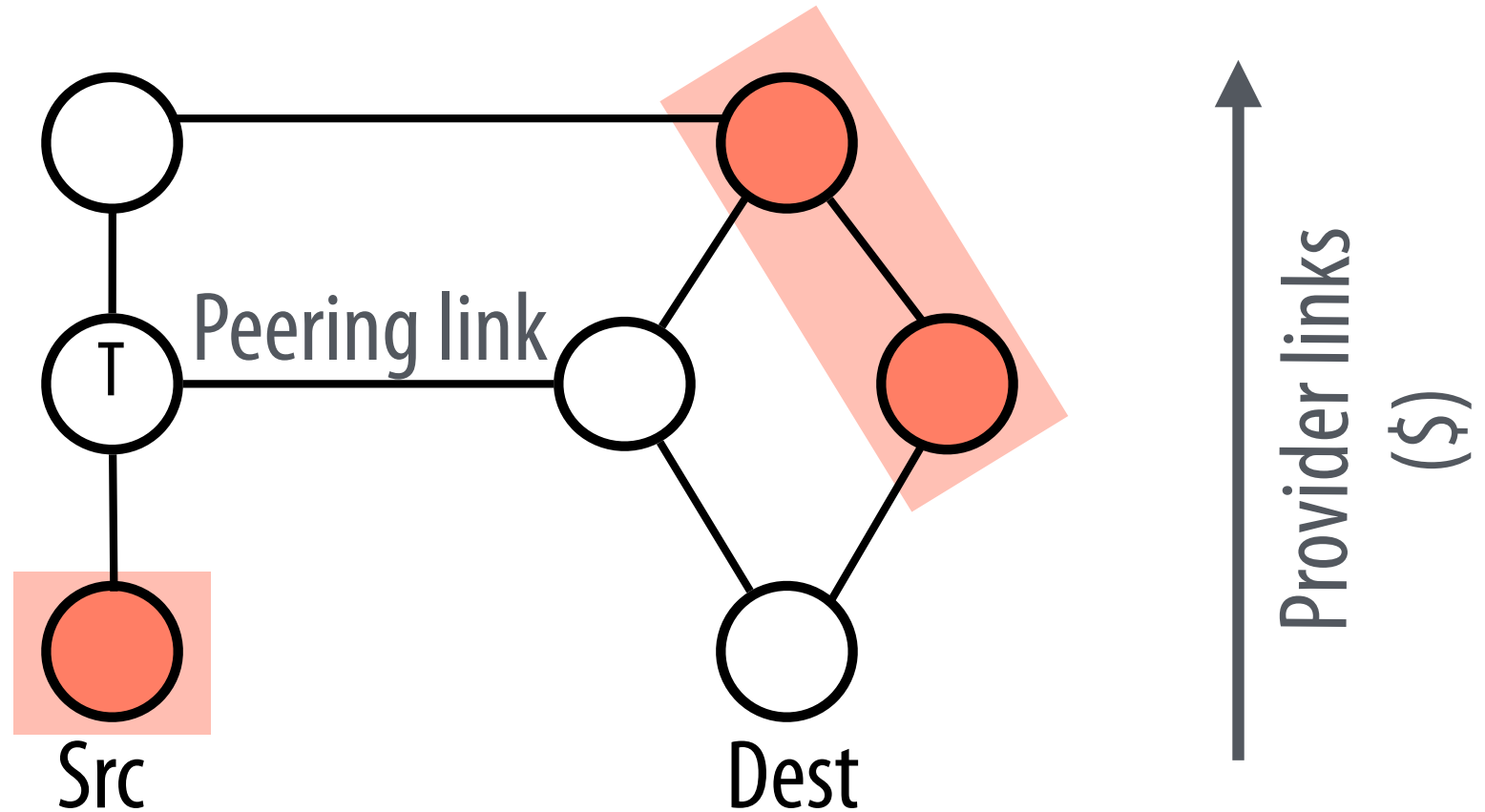No QoS   Only one best path

ASes can be spoofed

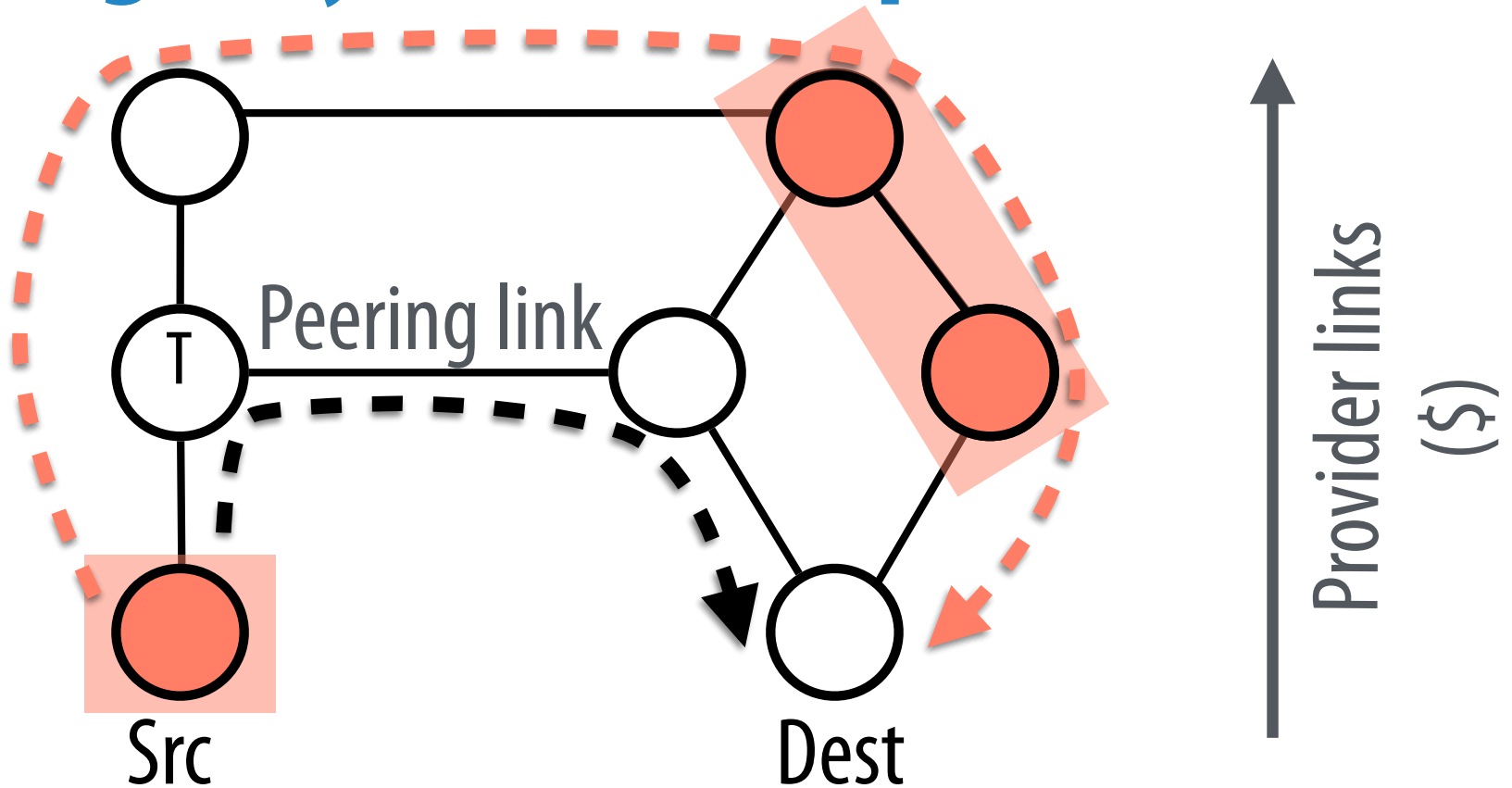⋮

BGP is rigid: requires neighbors to use it

Rigidity results in isolated islands

Peering link

Provider links ($)

Src   Dest

🔴 AS supports new protocol   ⚪ AS supports BGP

🟧 Island

Isolation dis-incentivizes deployment

Skirting rigidity with data-plane tunnels

Peering link

Provider links ($)

Src

Dest

AS supports new protocol · AS supports BGP

Island — Tunnel path — BGP path

Incentivizes non-deployers to fight evolution

Key contributions
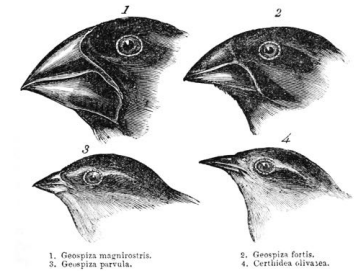
The two modest evolvability features

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

Evolvable Internet

+

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

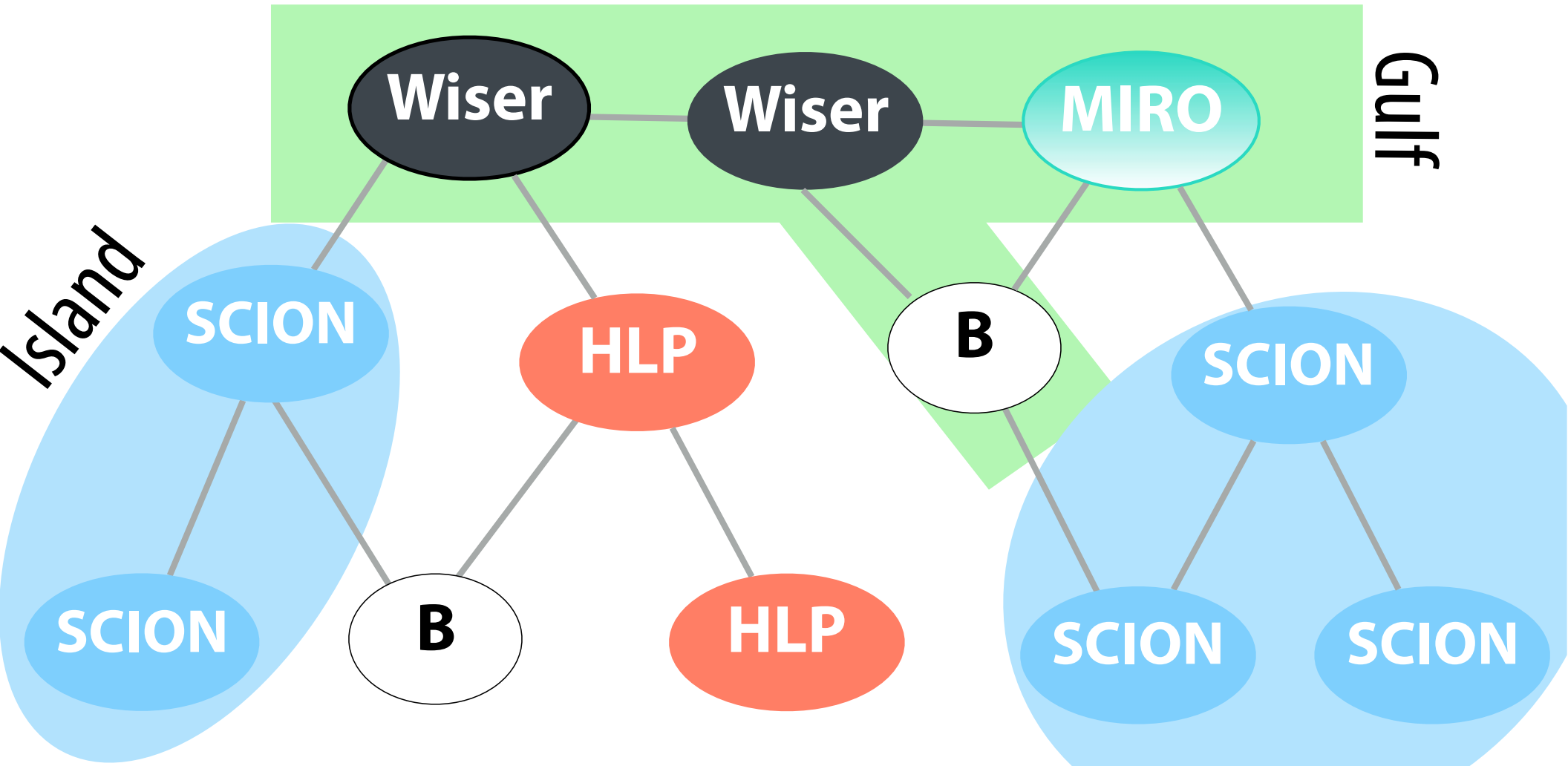**BGP ➡ mod. BGP**   **BGP // Services**   **BGP ➡ FIA**

Reqs   Reqs   Reqs

Global reqs

Pass-through support
(provided by BGP)

Multi-protocol structure

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An evolvable Internet

Gulf

Island

Wiser — Wiser — MIRO

SCION

HLP

B

SCION

SCION

B

HLP

SCION

SCION
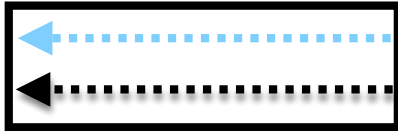
Runs many routing protocols

All ASes support a shared baseline (B)

Taxonomy of evolvability scenarios

	BGP ➡ mod. BGP	BGP // Services	BGP ➡ FIA
Properties	Extra ctrl info	✳	Different ctrl info
Ex.	Wiser, R-BGP	MIRO, Arrow, ✳	SCION, HLP, Pathlets

Incentives

	BGP ➡ mod. BGP	BGP // Services	BGP ➡ FIA
Deployers	Inc. benefits	Profits	Inc. benefits
Non deployers	Joint control	Future profits	Joint control

Reqs

	BGP ➡ mod. BGP	BGP // Services	BGP ➡ FIA
	Send across gulfs	Enable discovery	Send across gulfs
	Send in-band		Send in-band

Evolvability scenarios (FIA)

BGP ➥ FIA

Properties

Different ctrl info - - - - - - ➤ E.g., extra paths or link states
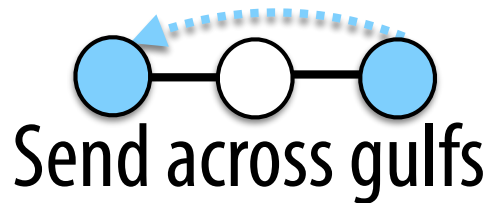
Ex.

SCION, HLP, Pathlets

Incentives
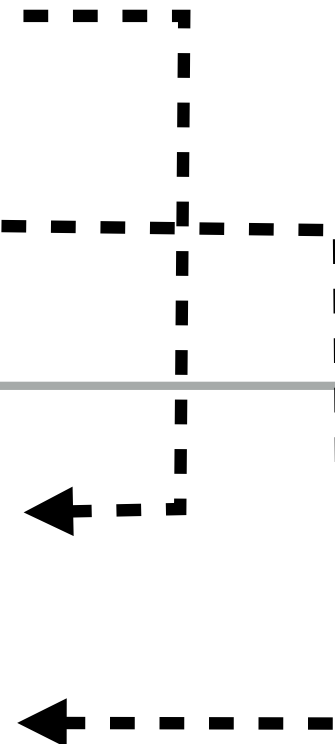
Deployers

Inc. benefits

Non deployers

Joint control
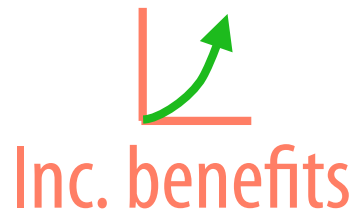
Reqs

Send across gulfs

Send in-band

Deploying SCION, a FIA protocol

Baseline advertisement ⬚

Packet hdr (IP + SCION)

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Deploying SCION, a FIA protocol

B

Gulf

Src

Island

Dest

☐ Baseline advertisement

▨ Packet hdr (IP + SCION)

14

Deploying SCION, a FIA protocol

Island

Gulf

B

Src

Dest

☐ Baseline advertisement

⬚ Packet hdr (IP + SCION)

15
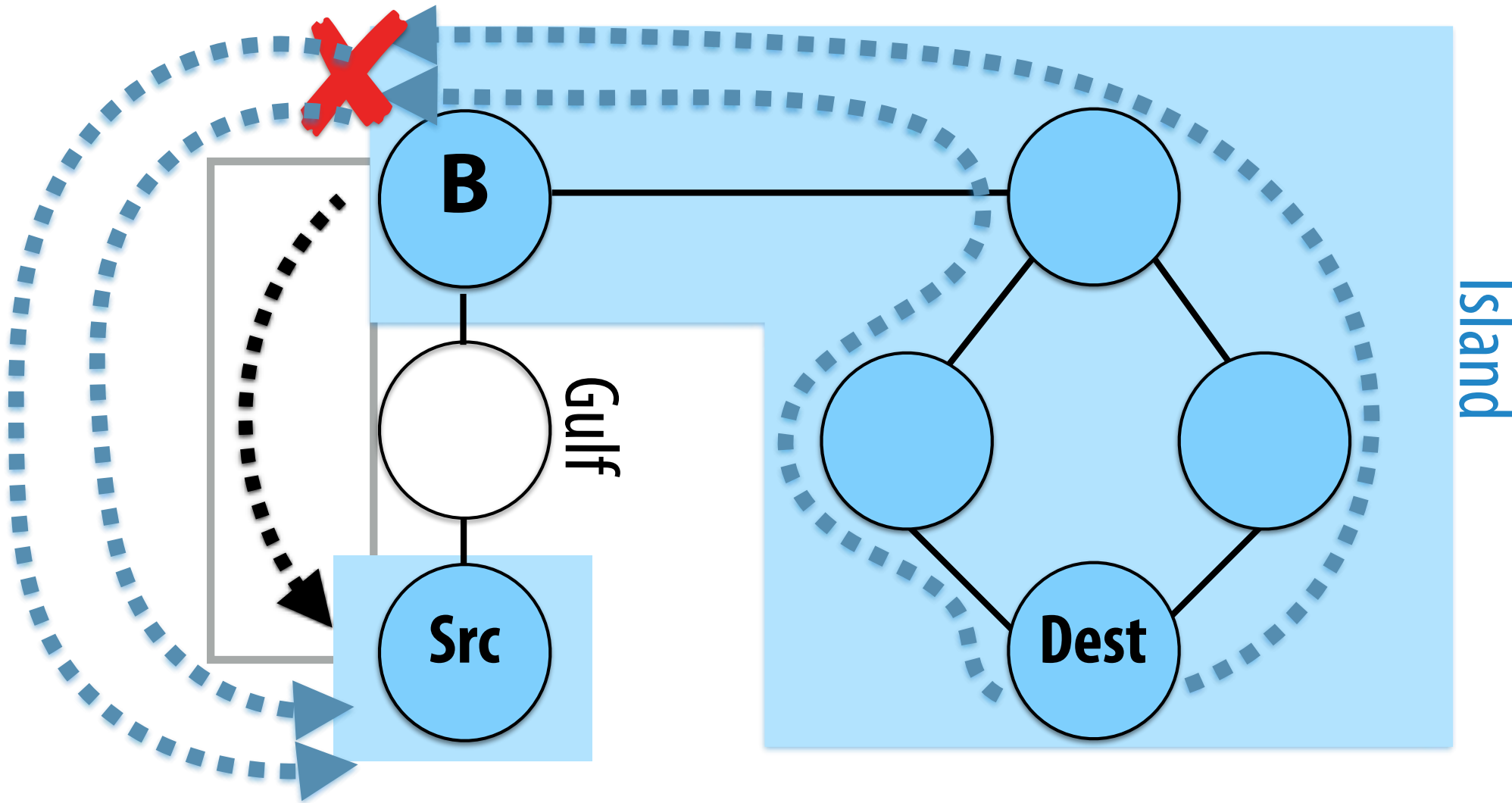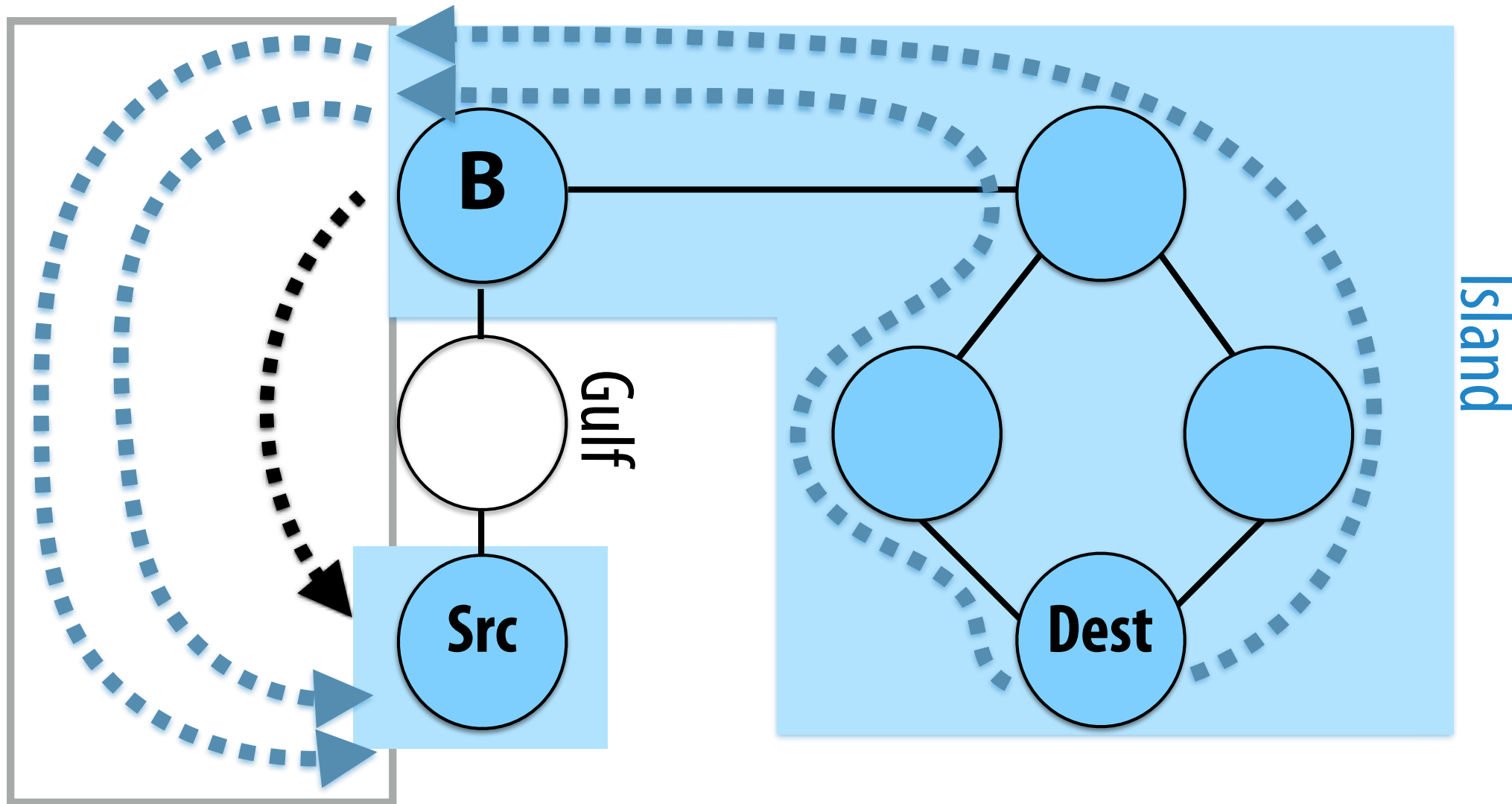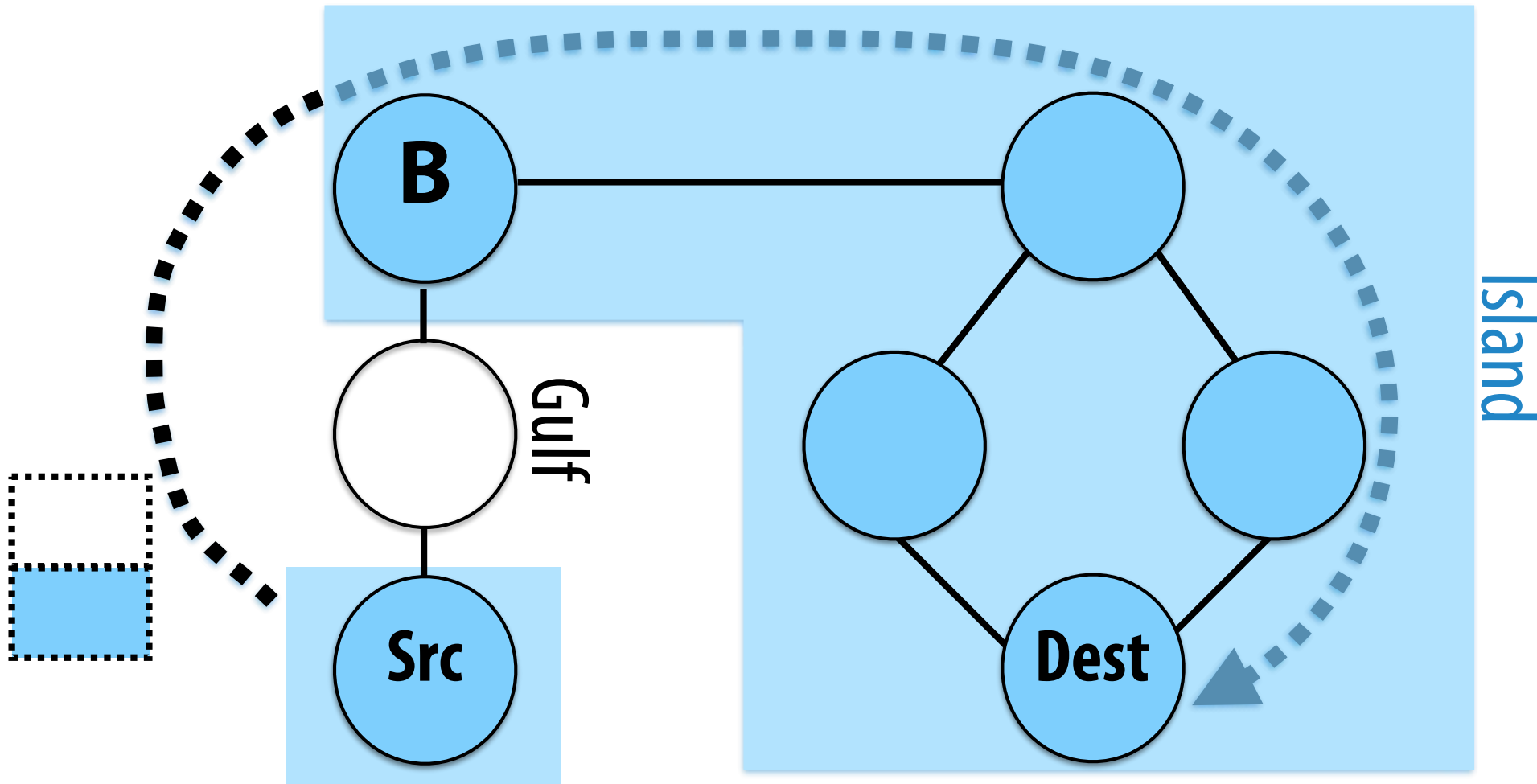
Global reqs for an evolvable Internet
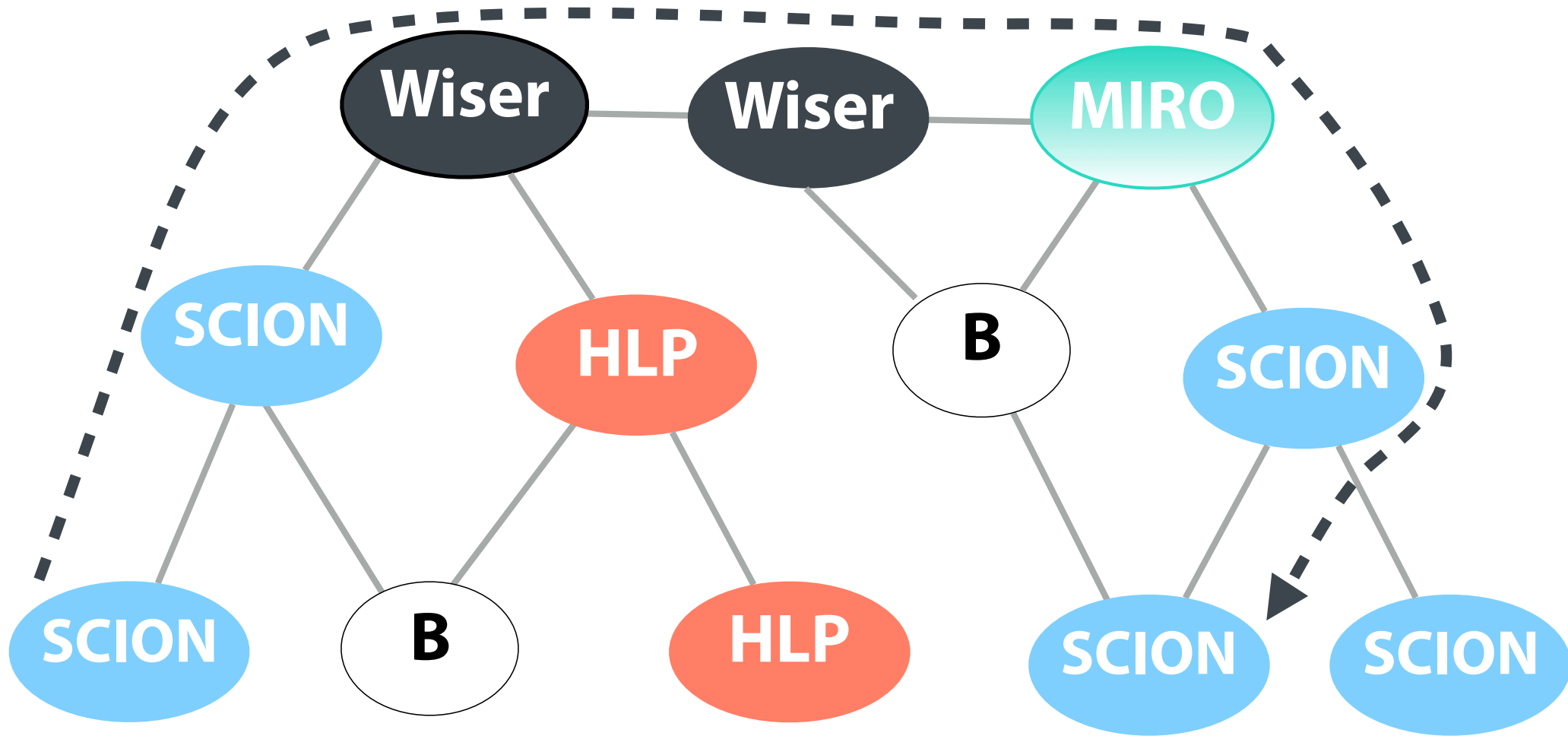
Inform islands about protocols on paths
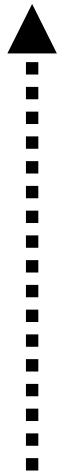
Provide common denominator for e-e paths

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Features

Requirements

Pass-through support

Disseminate across gulfs
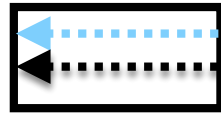
Disseminate in-band

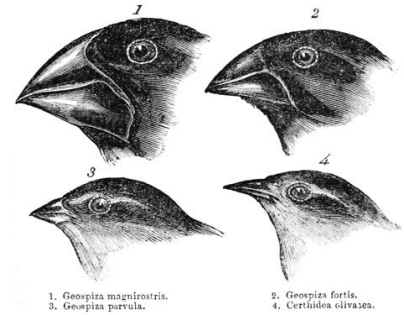Enable discovery

Multi-protocol data structure

Inform islands about protocols on paths

Provide common denominator for e-e paths

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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

=
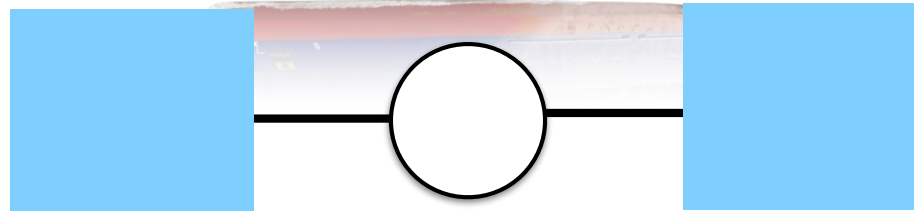
Island ⬜──◯──⬜ Island

D-BGP's integrated advertisements

Dest. address: 128.2.42.52/24

Path vector

AS #	Island ID

- - - → 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

AS #	Island ID
8	G
4 3 2 1	R

D-BGP

HLP

SCION

Dest.

Island ID: G

8

Island ID: R

4

2

3

1

Dest

An IA for a path
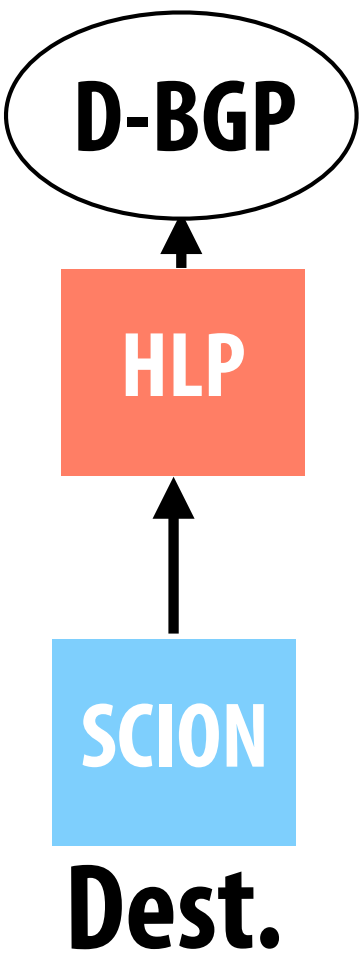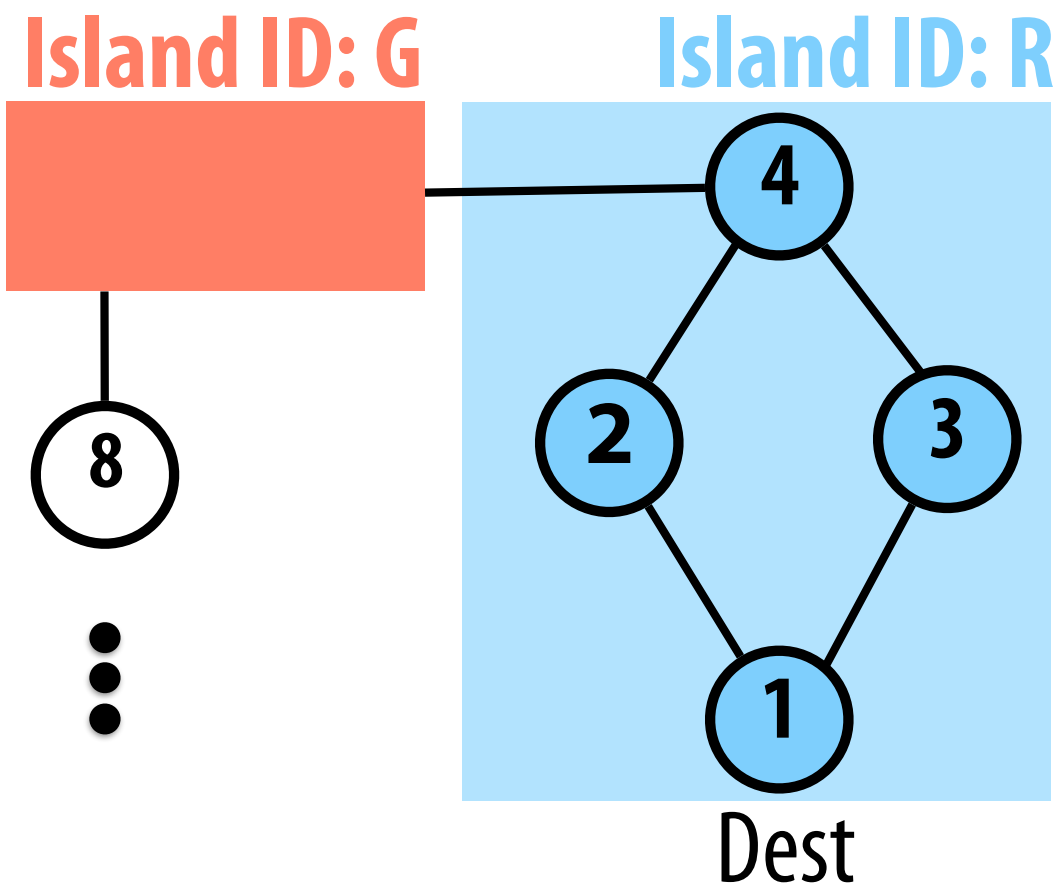
Dest. address: 128.2.42.52/24

	Path vector		Island desc.			Proto desc.	
	AS #	*Island ID*	*Proto(s)*	*Fields*	*Value(s)*	*D-BGP*	
D-BGP	8						
HLP		G				Origin	Next hop 132.2.5.1
SCION	4 3 2 1	R	SCION	Within-island paths	Path 1 Path 2	E	

Dest.
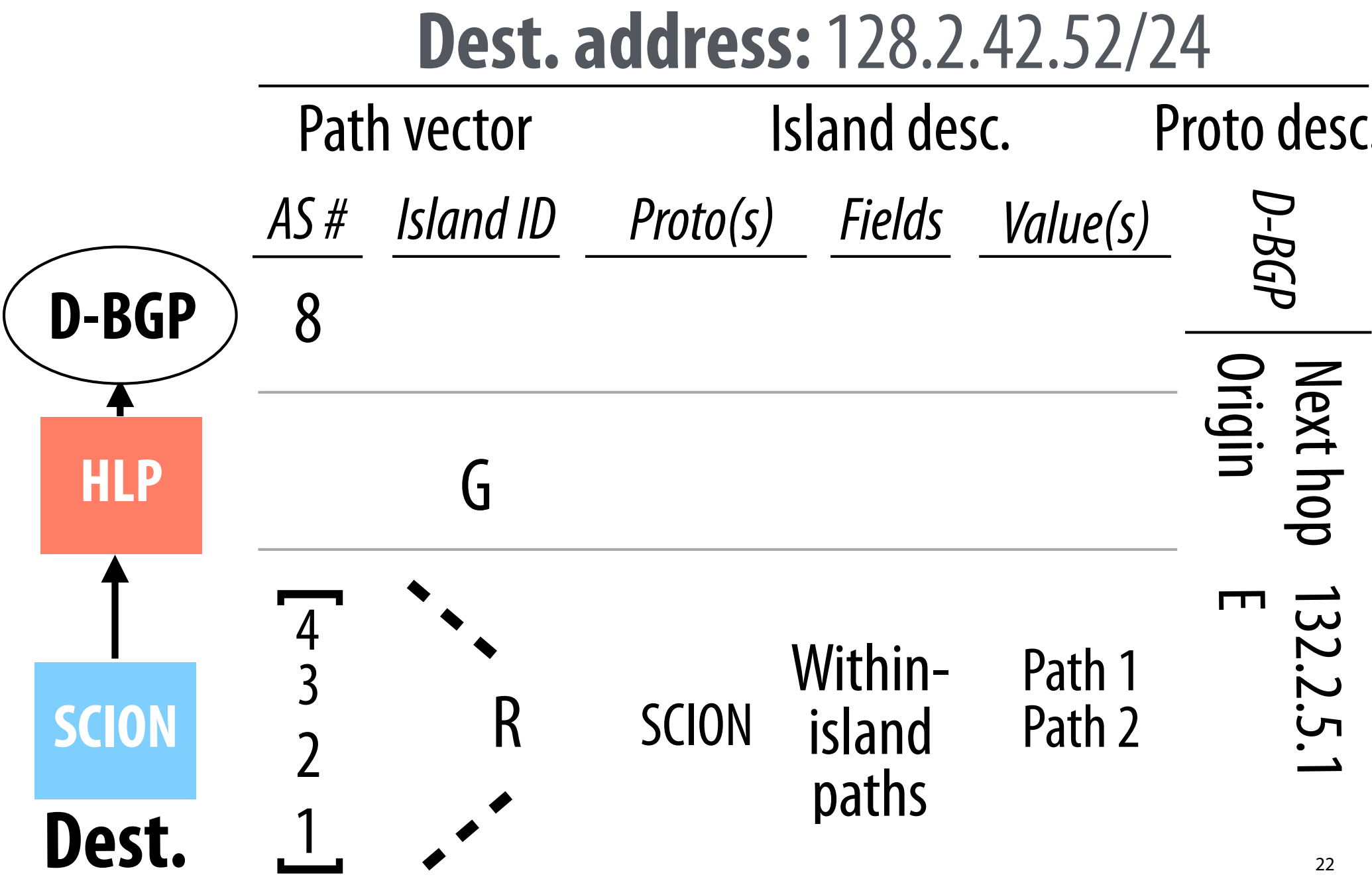
Outline
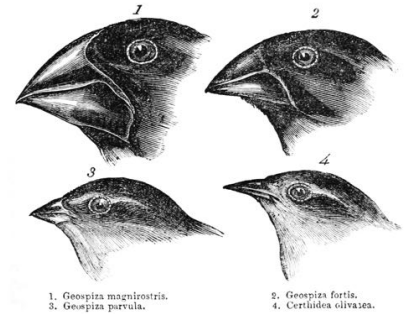
Evolvability features

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

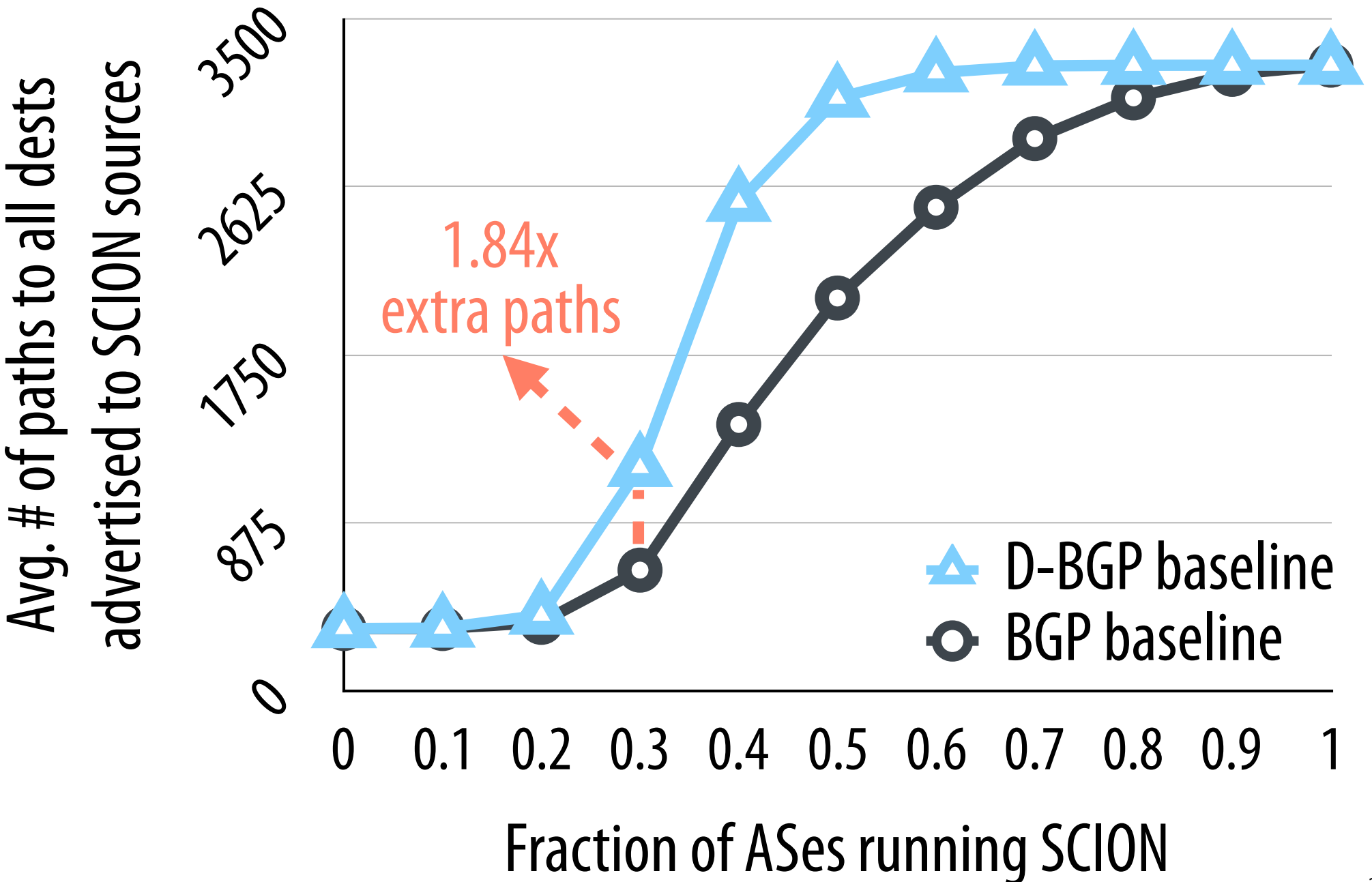## Explored benefits as function of adoption

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 ➡ Evol~~X~~ability

- Two features sufficient for evolvability

- D-BGP provides large evolvability benefits