iBGP Deceptions: More Sessions, Fewer Routes

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Breaking News

Adding a single iBGP session can result in iBGP distributing *fewer* routes

iBGP Deceptions:
More Sessions, Fewer Routes

Introduction and Motivation

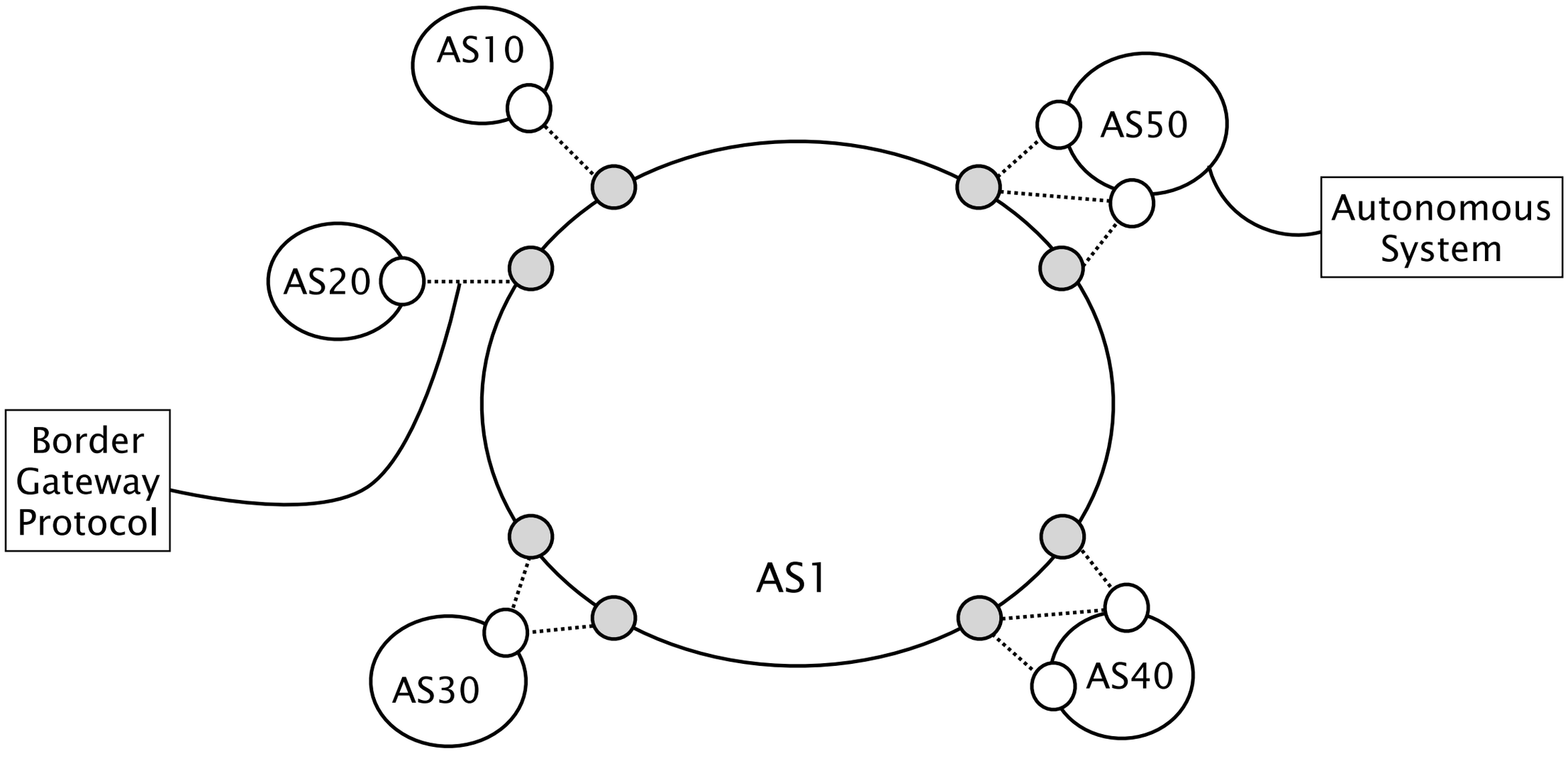
Dissemination correctness

Revisiting the state-of-the-art

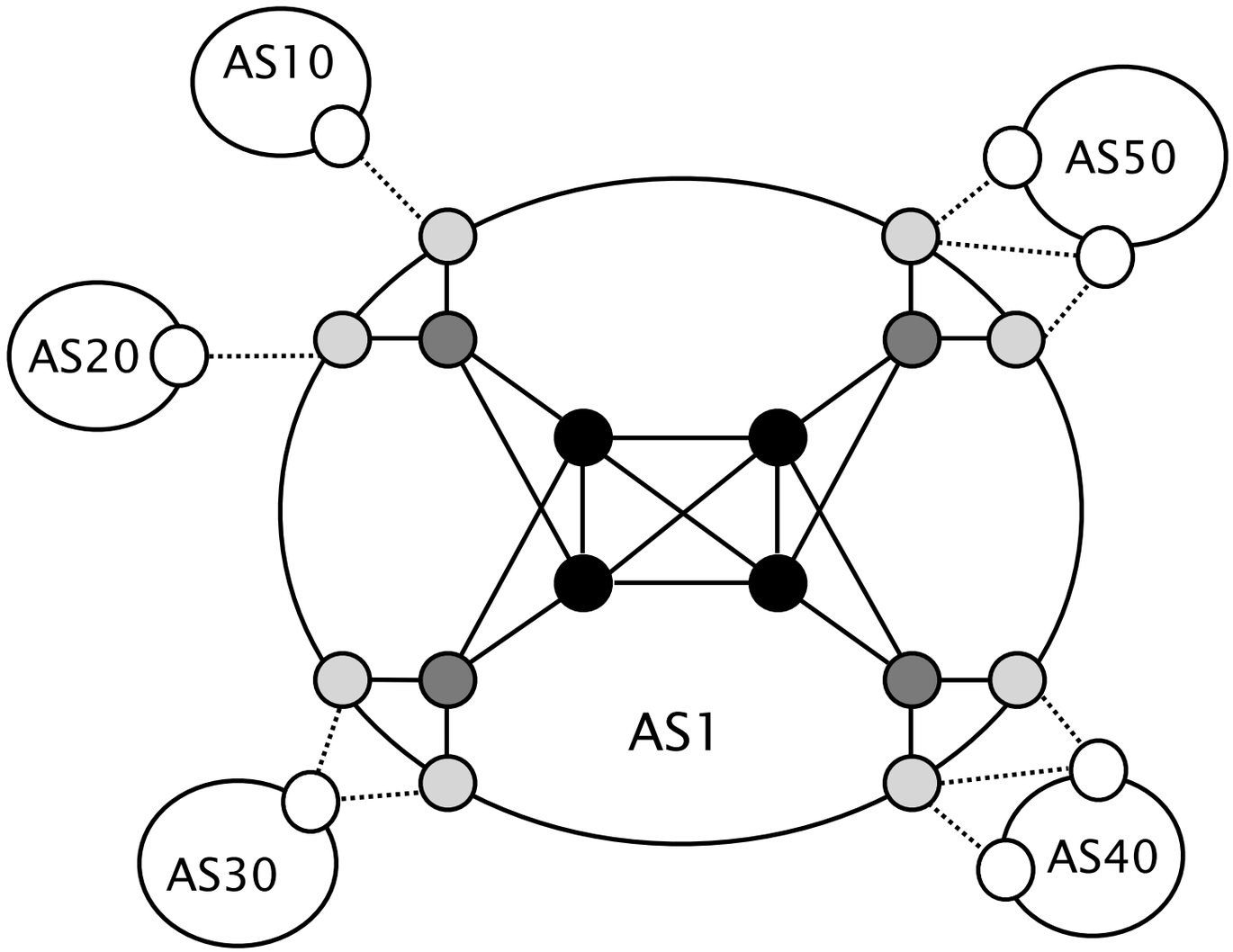
Conclusion

iBGP Deceptions:
More Sessions, Fewer Routes

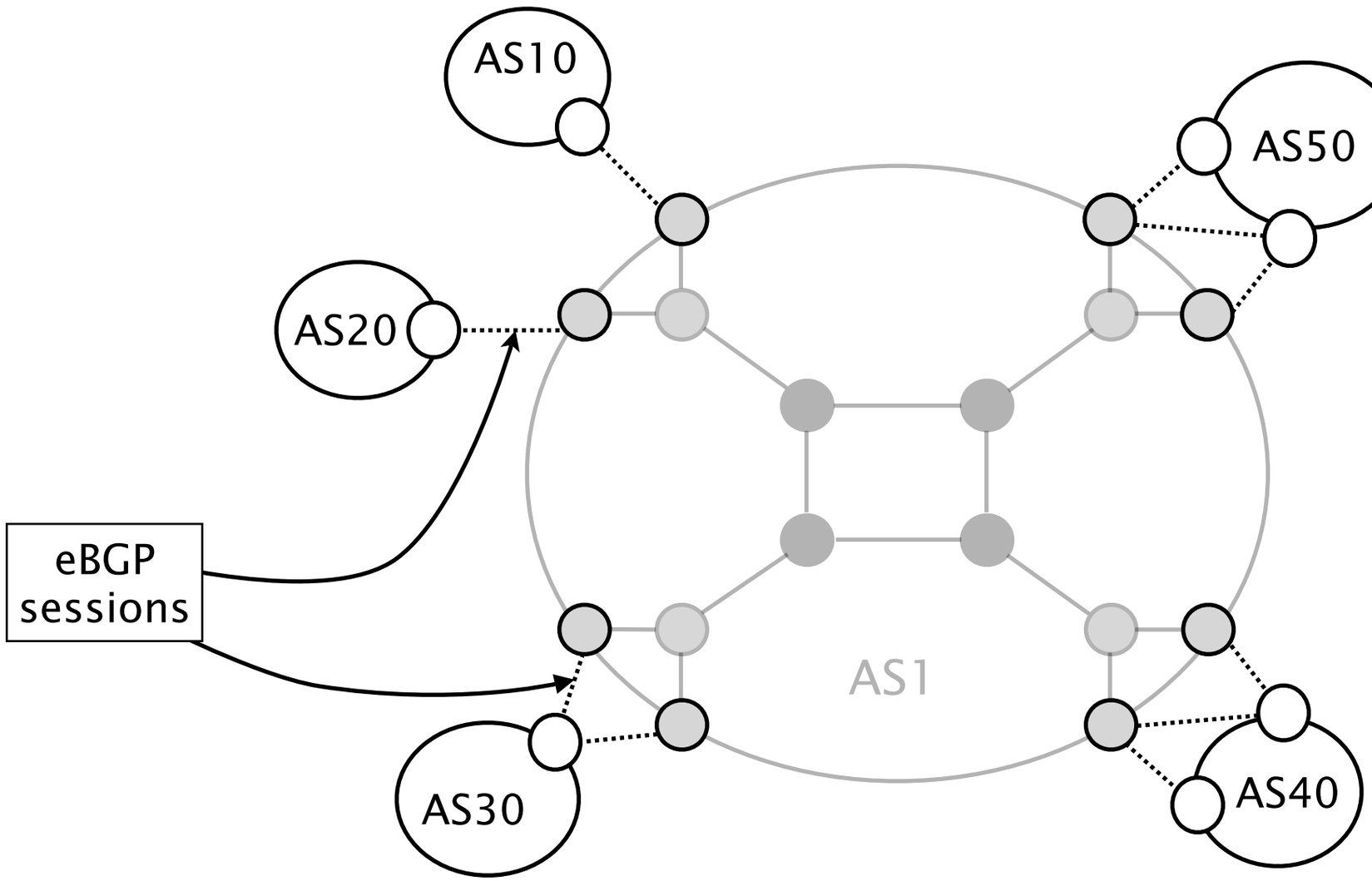
BGP is *the* inter-domain routing protocol used today



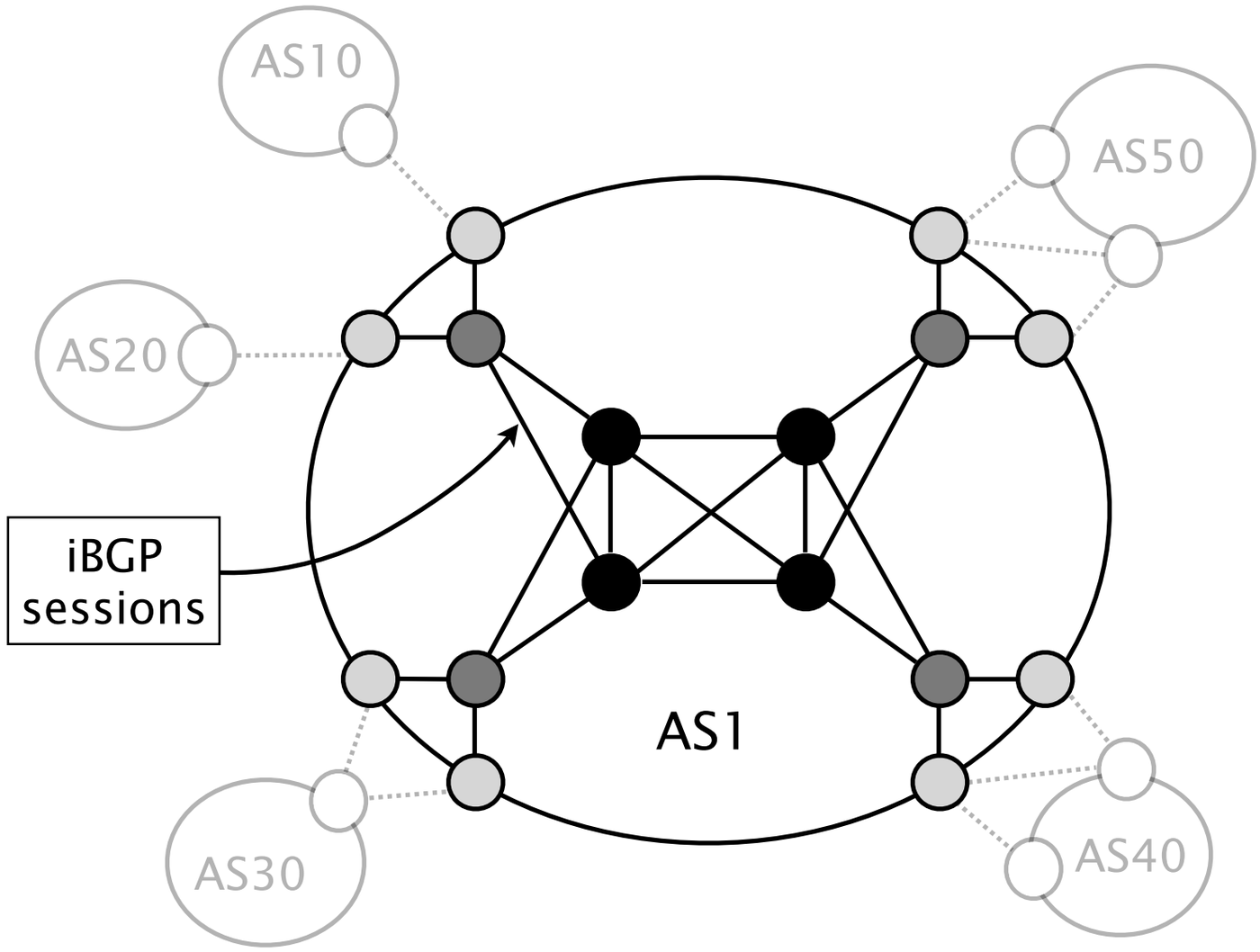
BGP comes in two flavors



external BGP (eBGP) exchanges reachability information between ASes

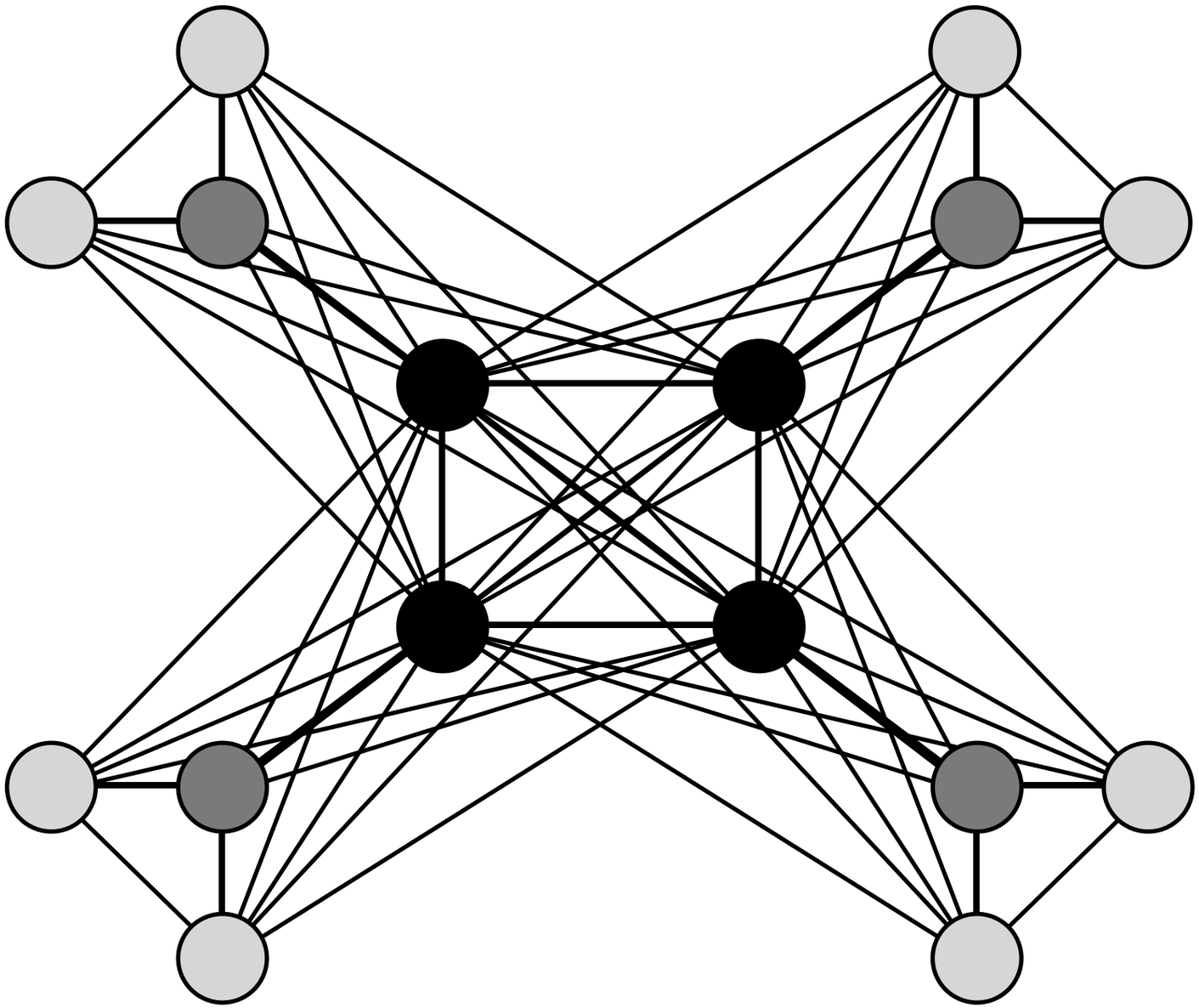


internal BGP (iBGP) distributes externally learned routes within the AS



In this talk, we take the perspective of a single AS and focus on iBGP

Plain iBGP mandates a full-mesh of iBGP sessions

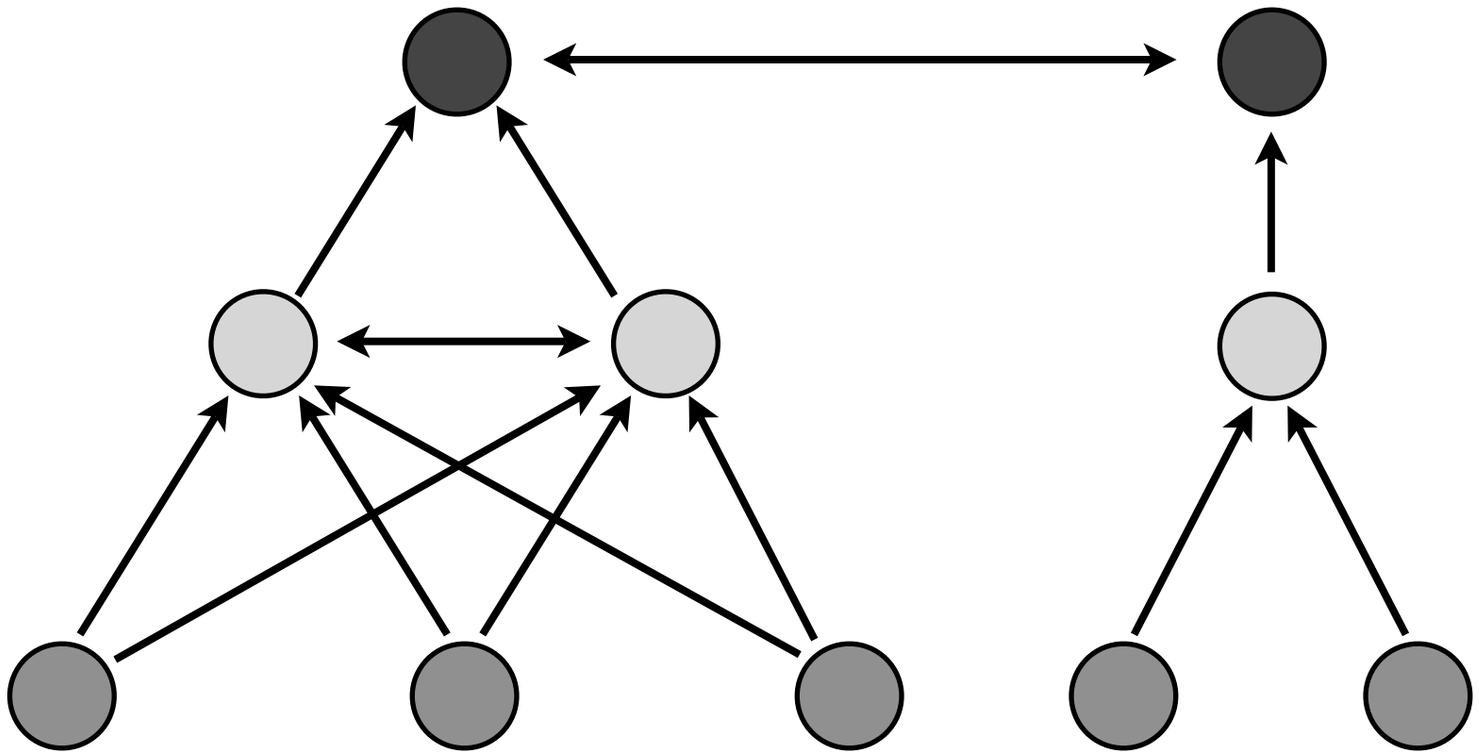


$O(n^2)$ iBGP sessions where *n* is the number of routers

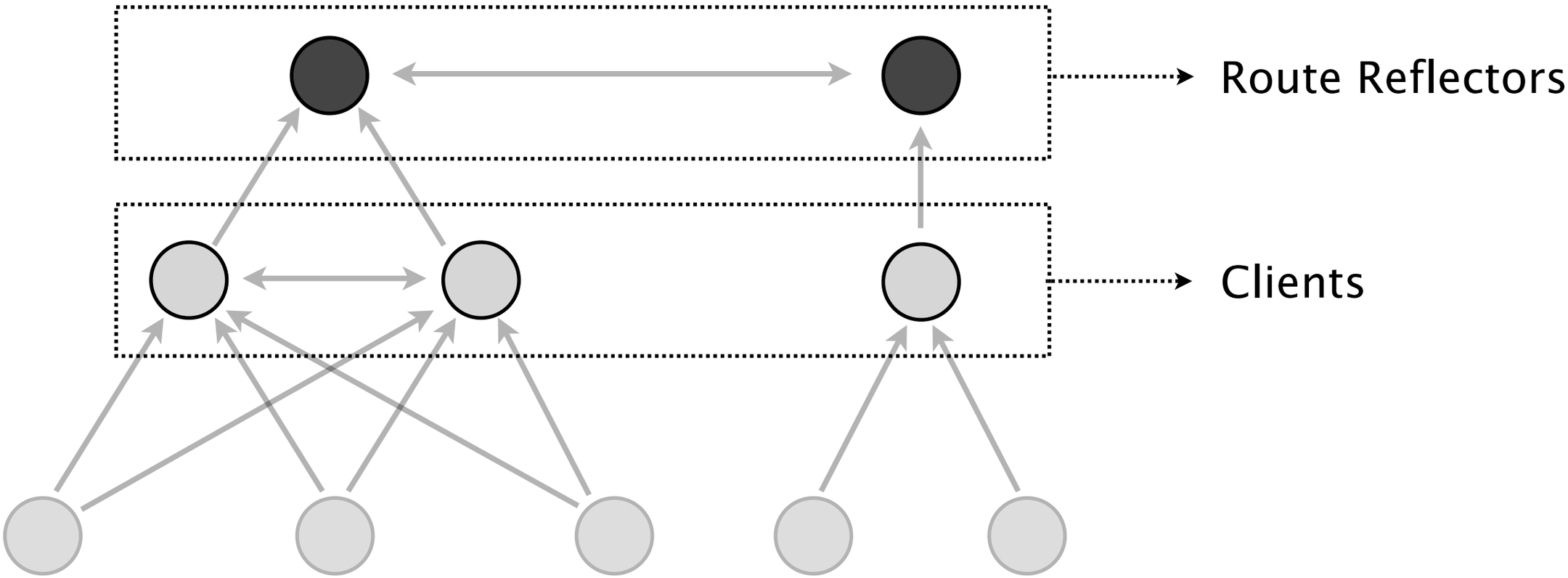
... quickly becomes totally *unmanageable*

Fair warning: some sessions are missing

With Route Reflection, iBGP routers are organized in a hierarchy



Route Reflectors relay updates to iBGP neighbors



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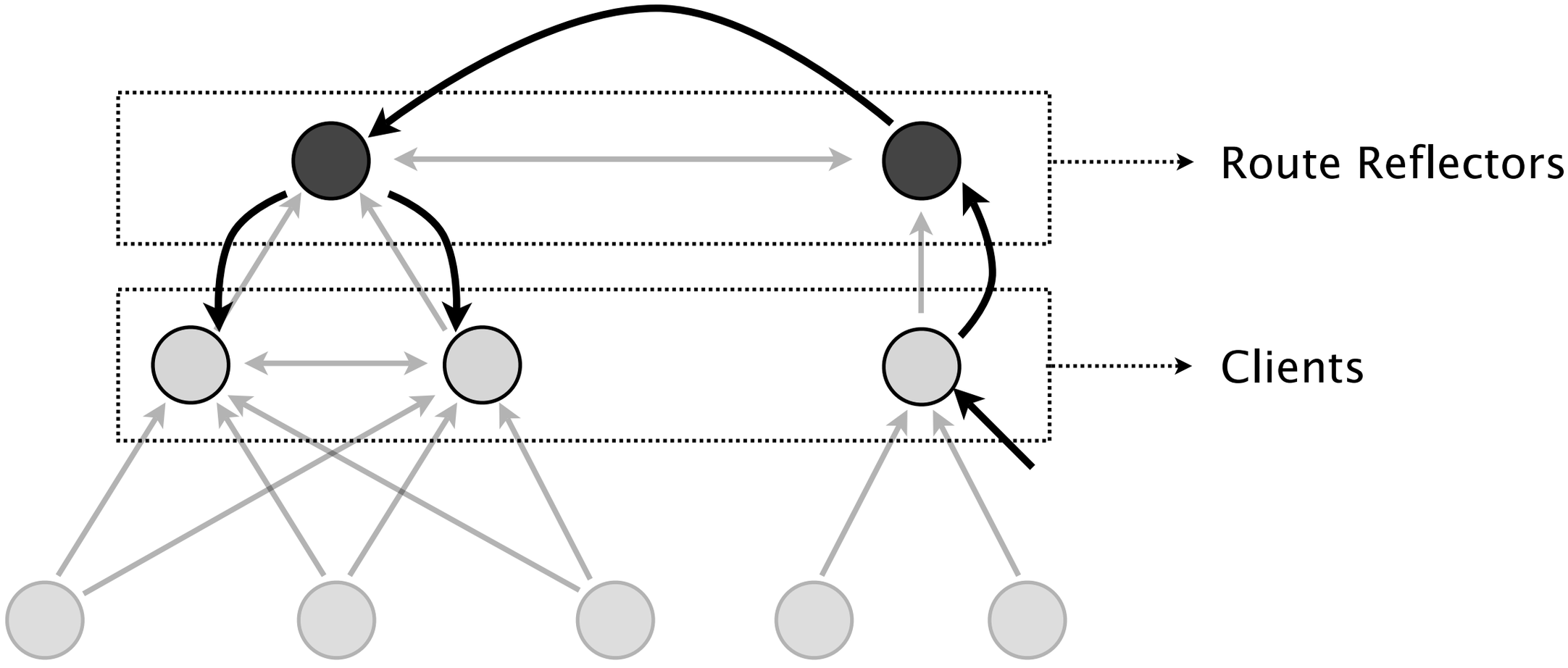
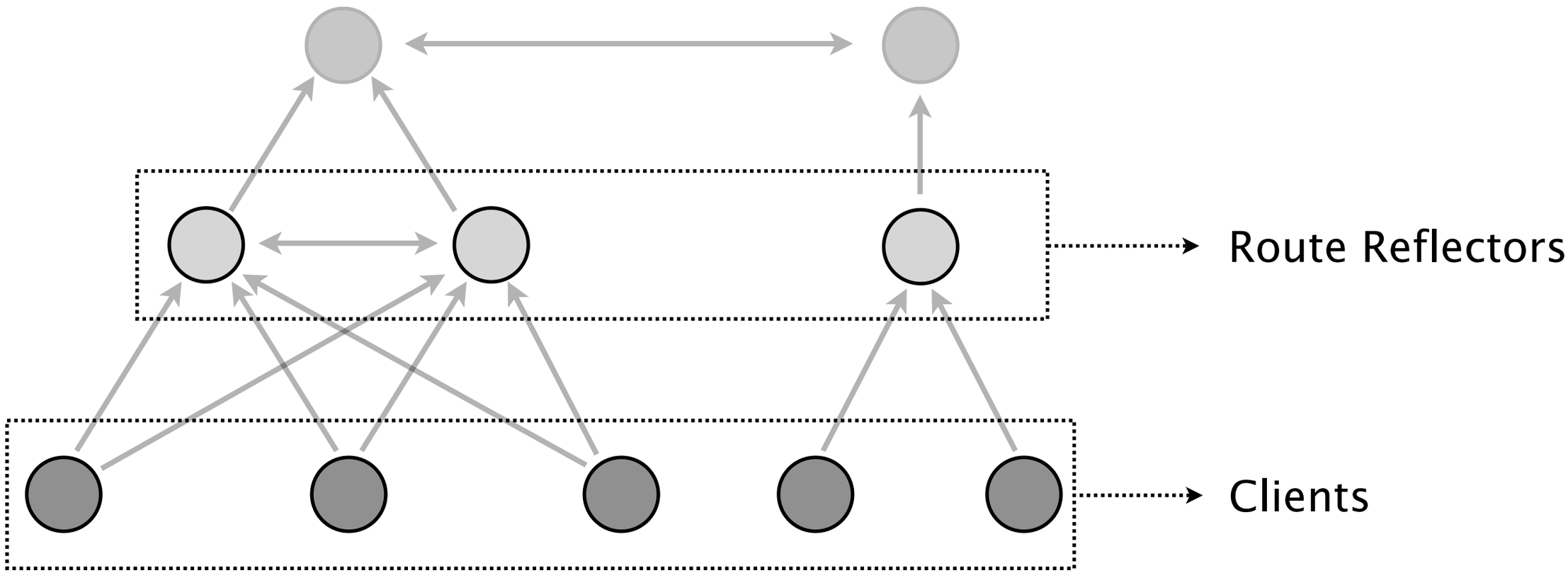


Several layers of Route Reflection can be built



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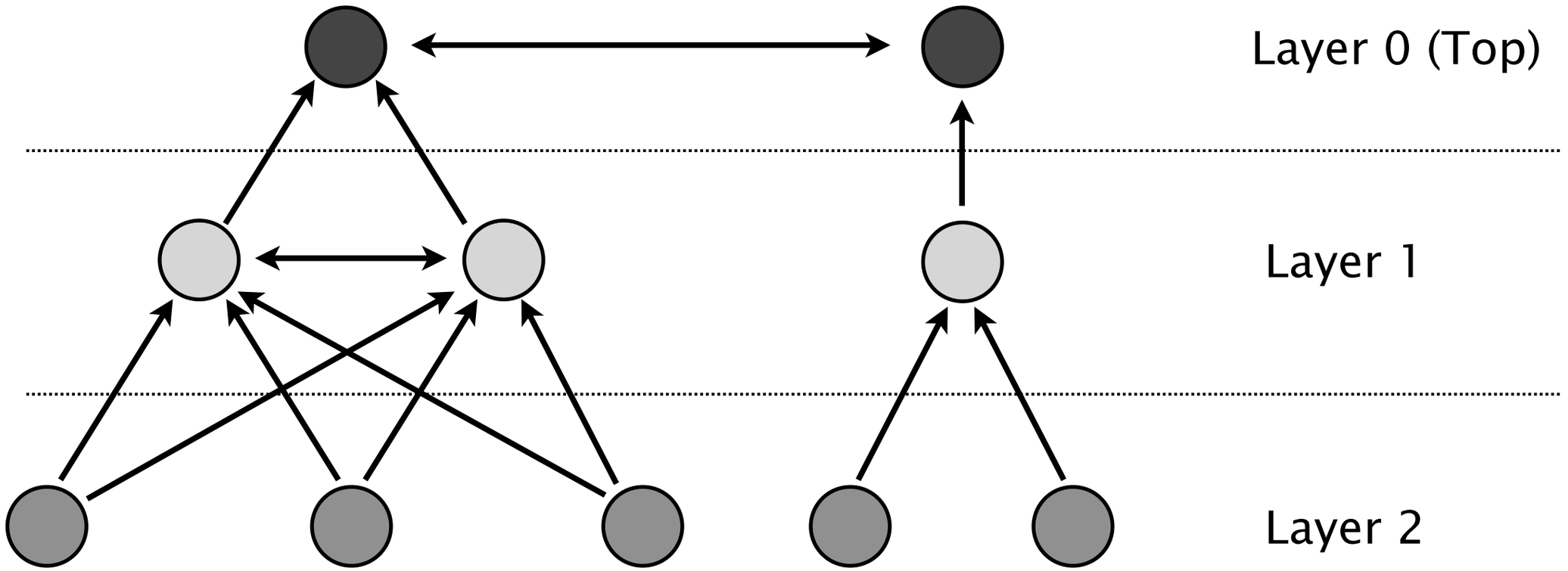
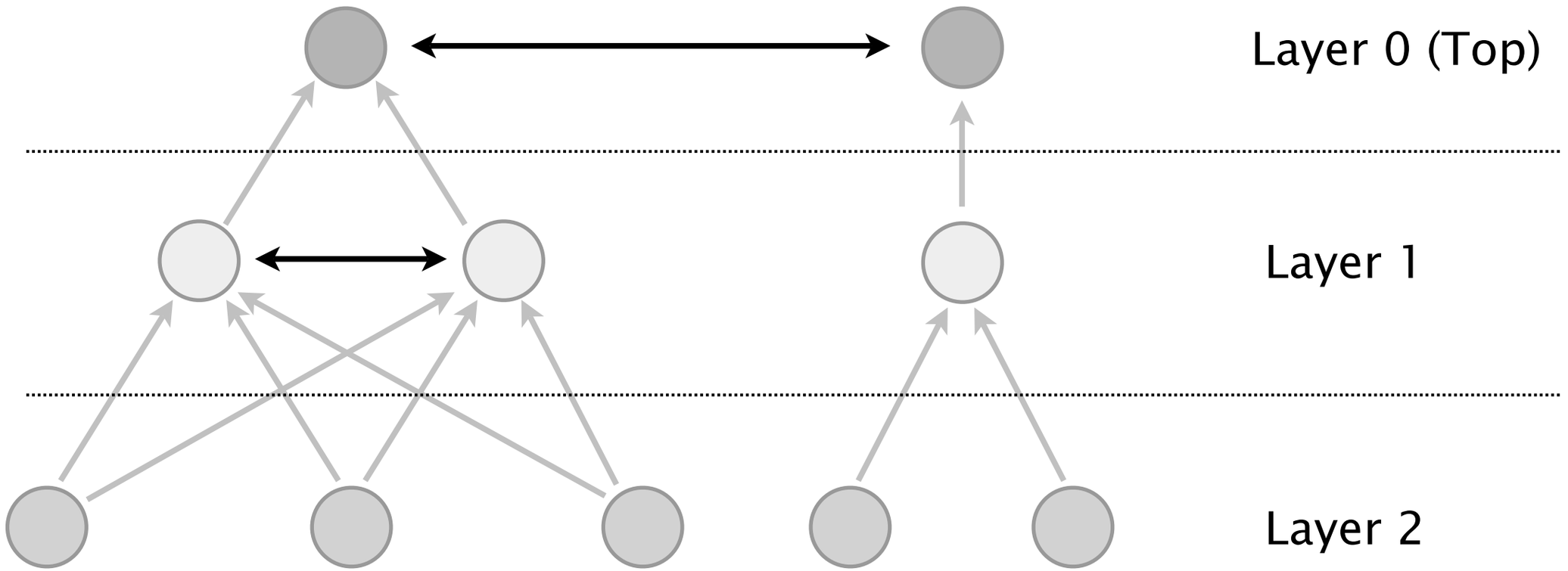
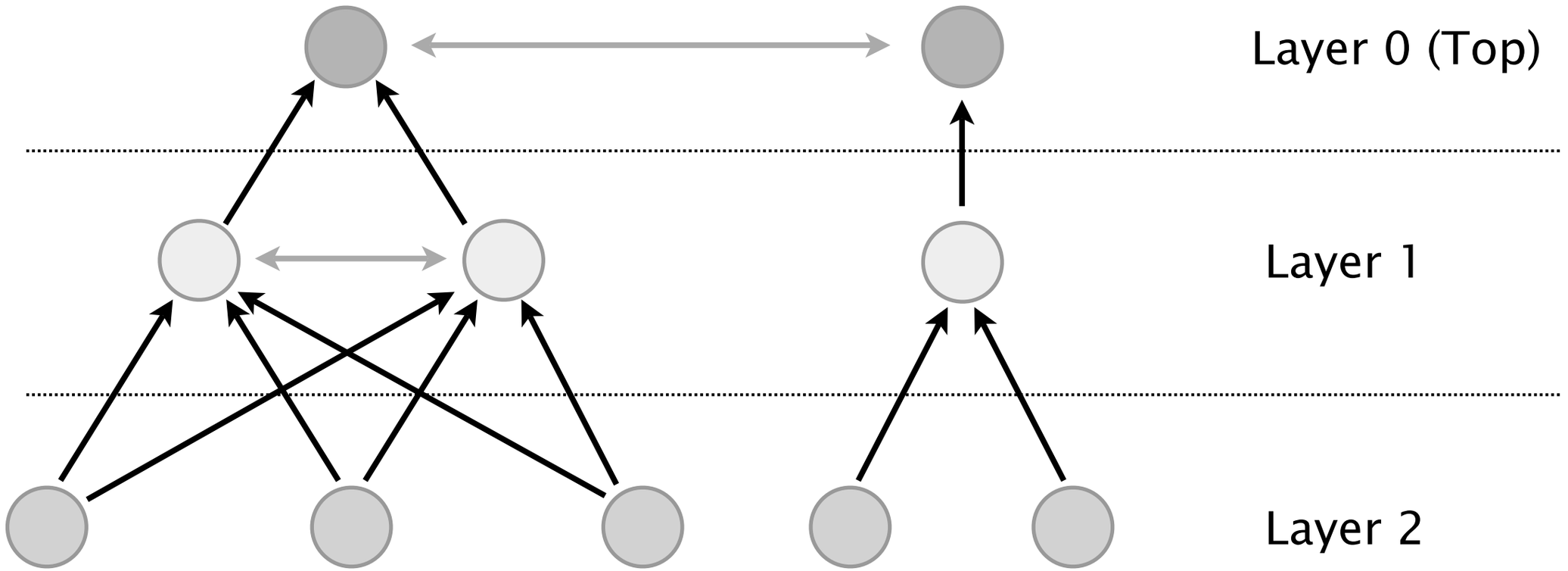


OVER sessions connect iBGP peers

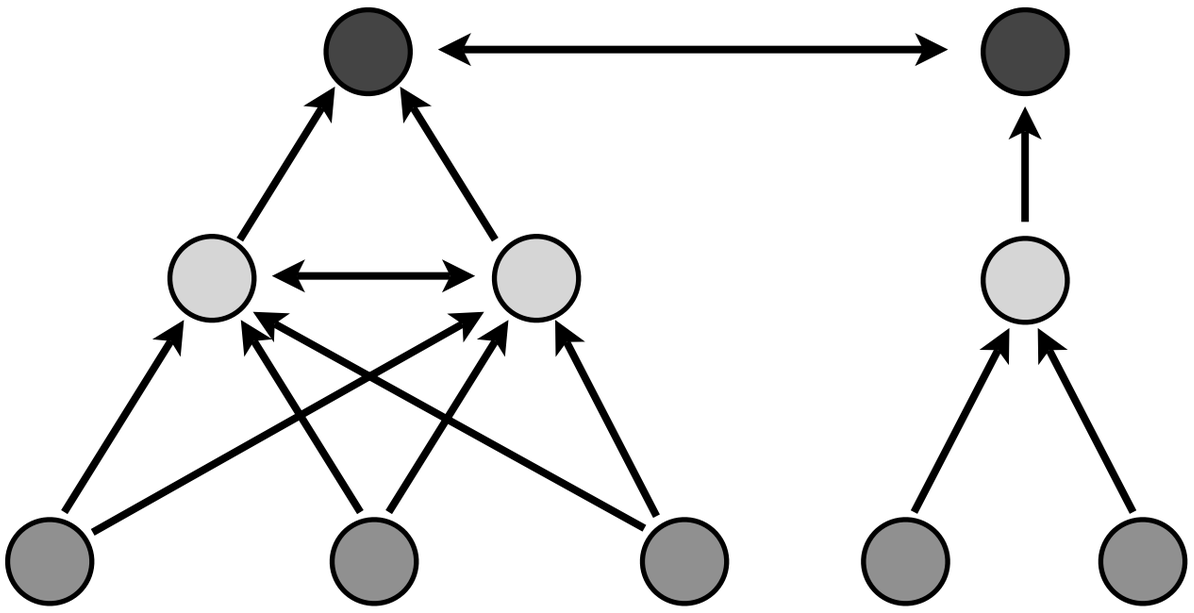


UP/DOWN sessions connect a Route Reflector to its client(s)



Best routes are allowed to flow on valid signaling paths only

Valid signaling path match the UP* OVER? DOWN* regular expression

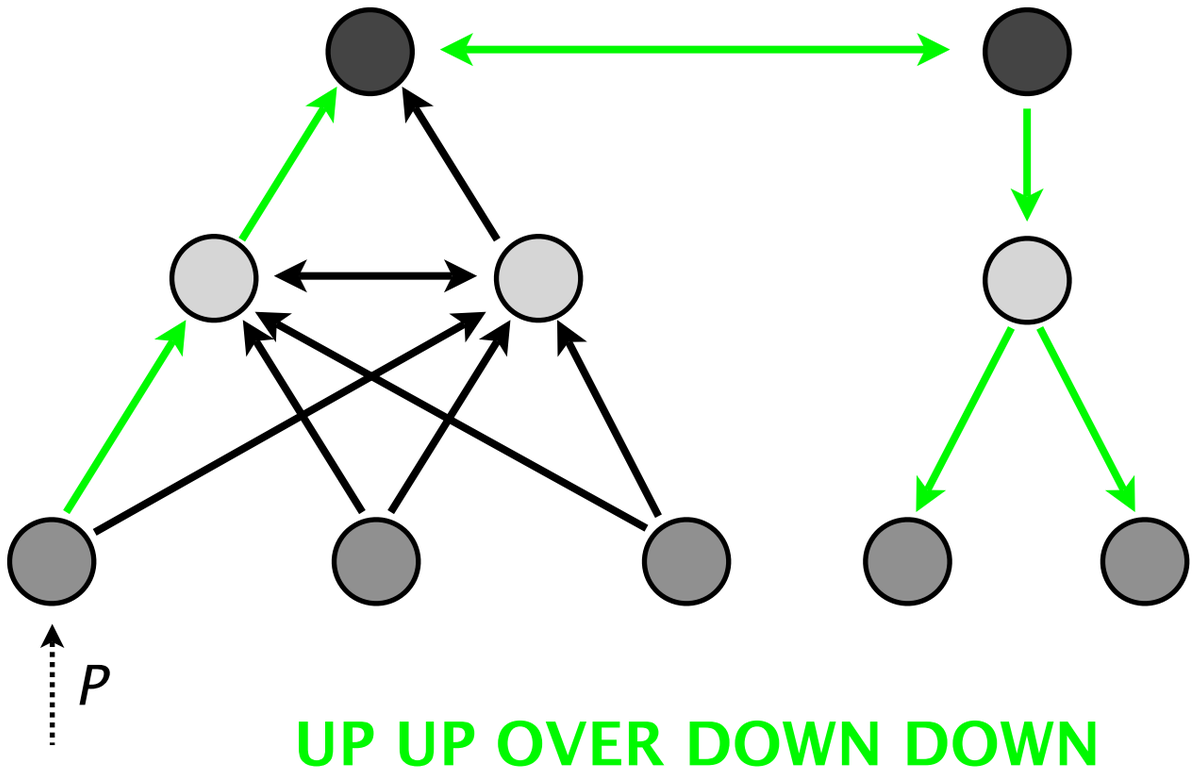


BGP Propagation rules

	To client	*To peer/RR*
From client	✓	✓
From peer/RR	✓	✗

Routes are allowed to flow on valid signaling paths only

Valid signaling path match the UP* OVER? DOWN* regular expression



UP UP OVER DOWN DOWN

BGP Propagation rules

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Routes are allowed to flow on valid signaling paths only

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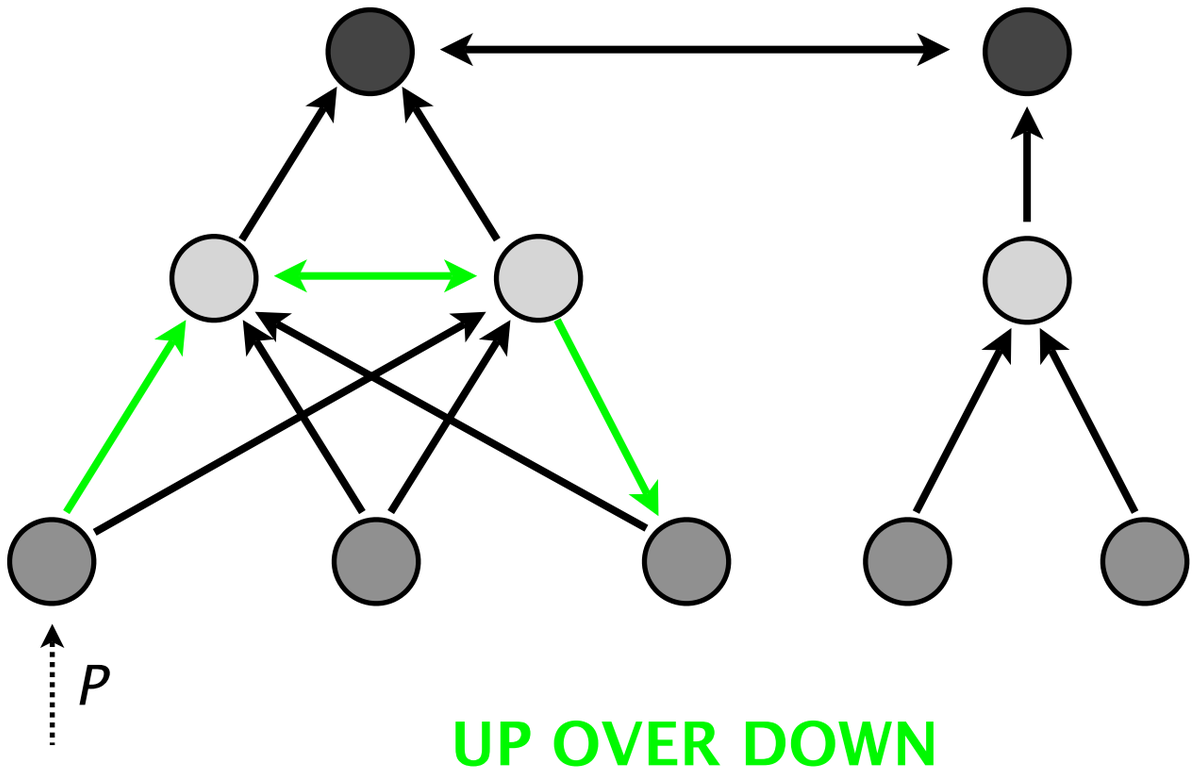

UP OVER DOWN

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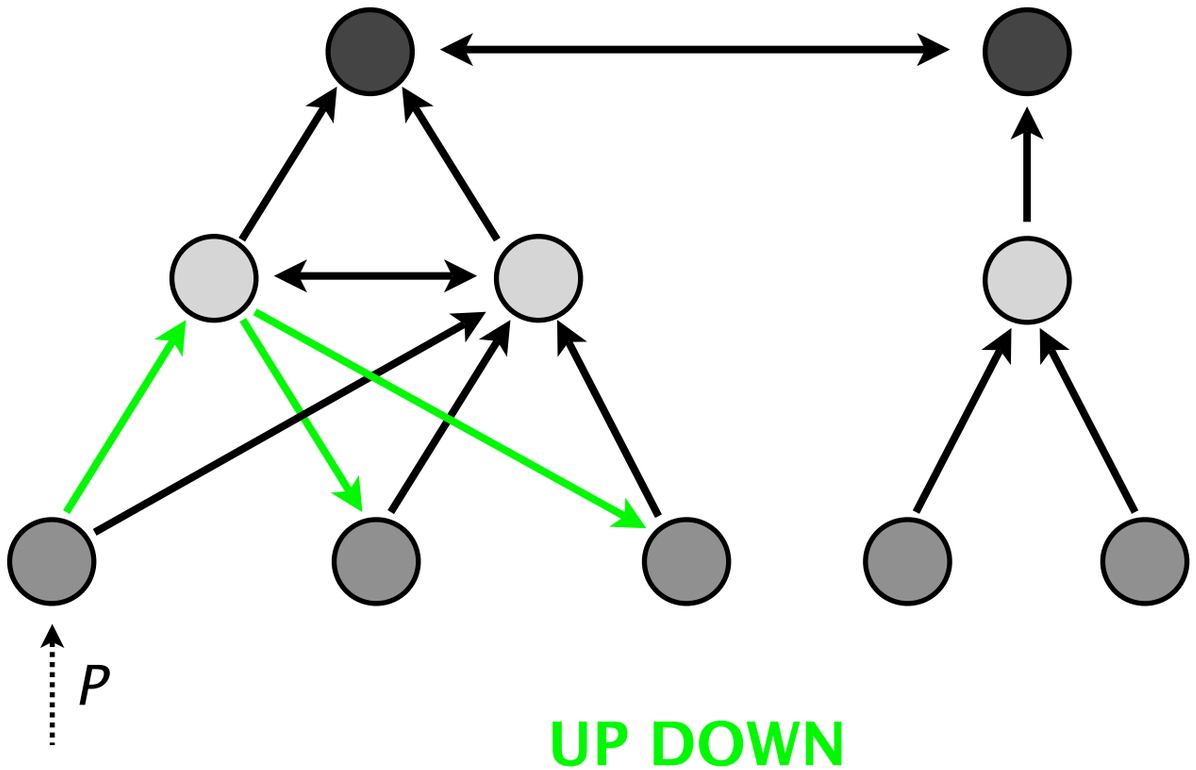

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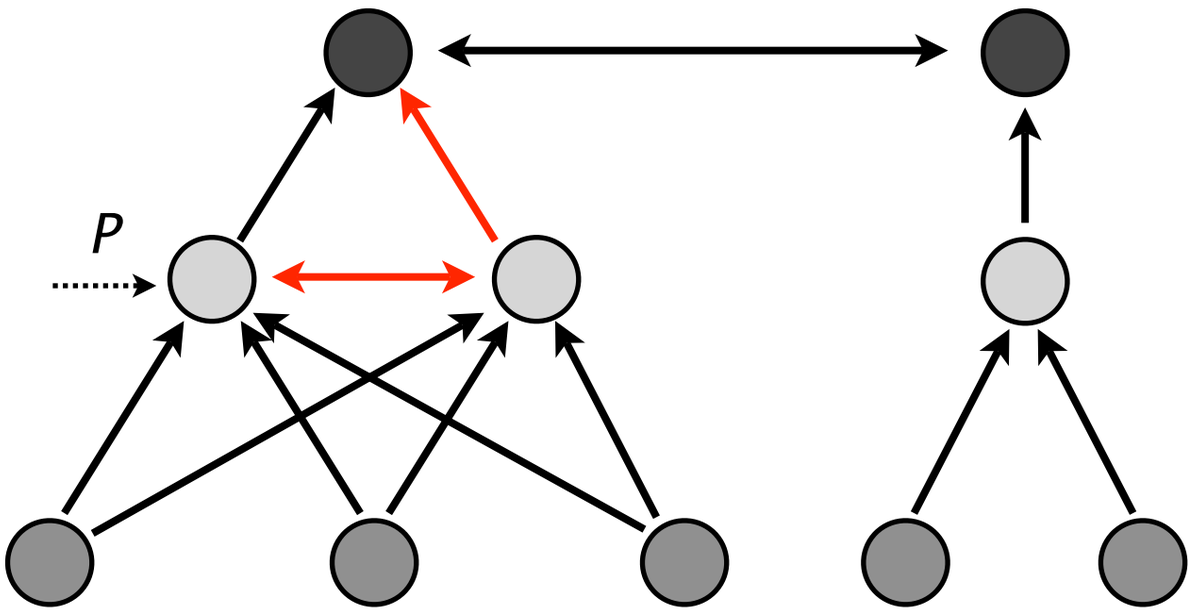


OVER UP

BGP Propagation rules

	To client	*To peer/RR*
From client	✓	✓
From peer/RR	✓	✗

Breaking News

Adding a single iBGP session can result in iBGP distributing fewer routes

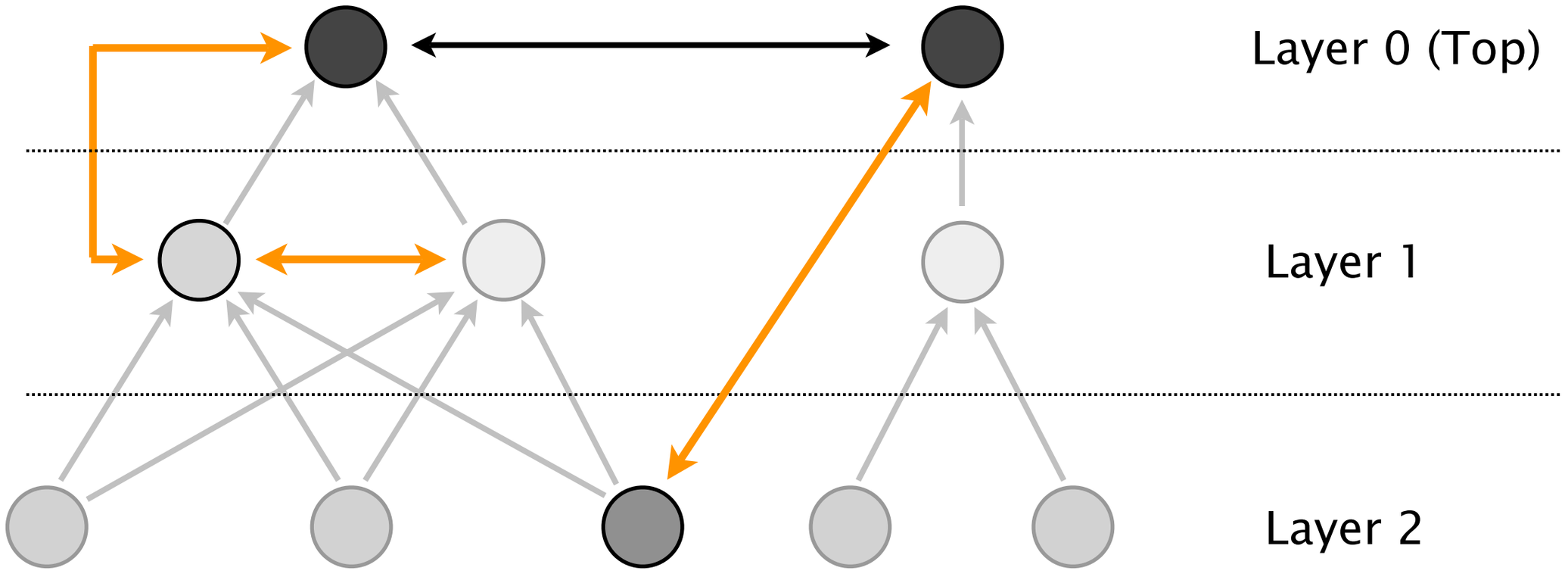
Breaking News

Adding *a single spurious OVER* can result in iBGP distributing fewer routes

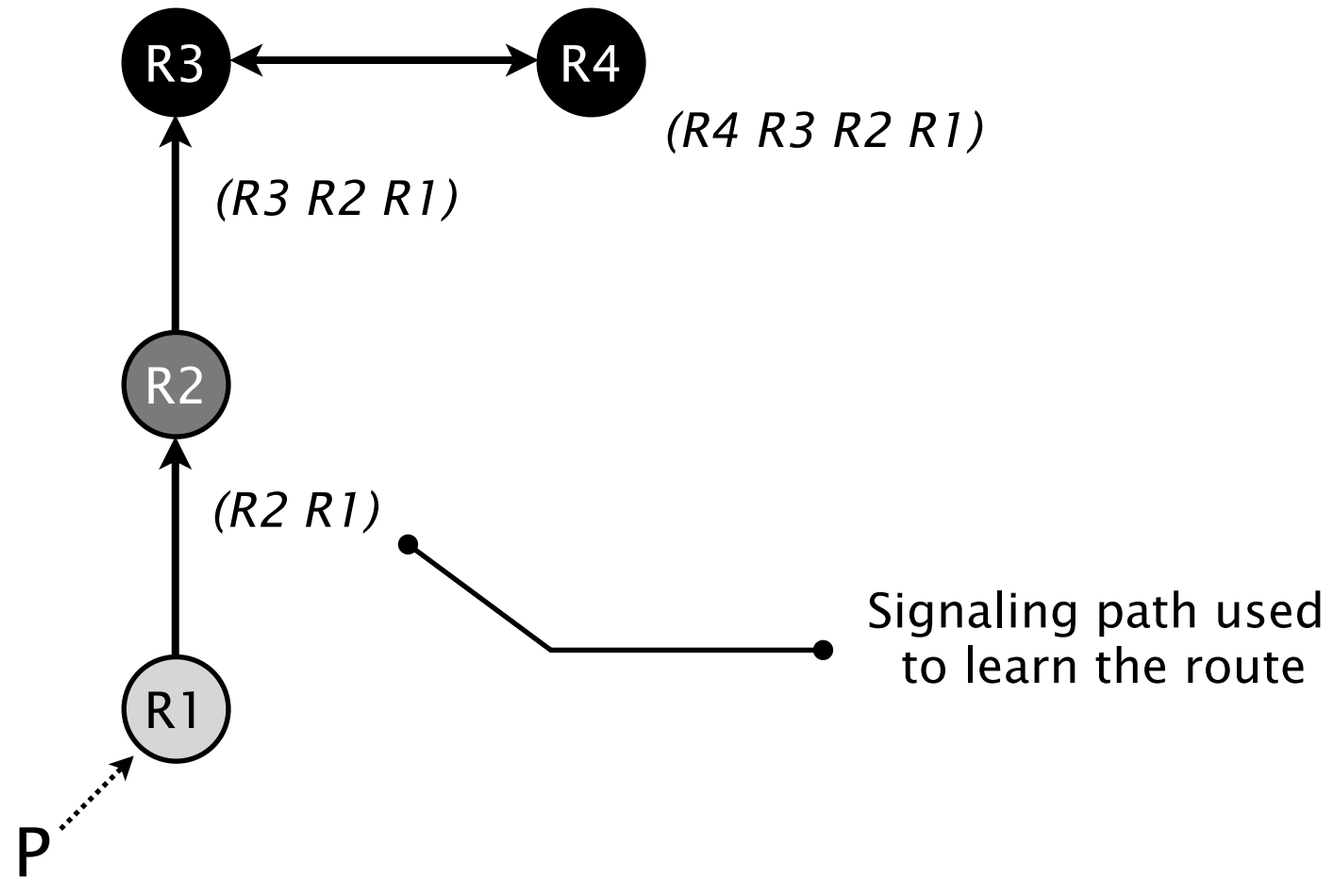
A spurious OVER is a special type of OVER

Spurious OVER

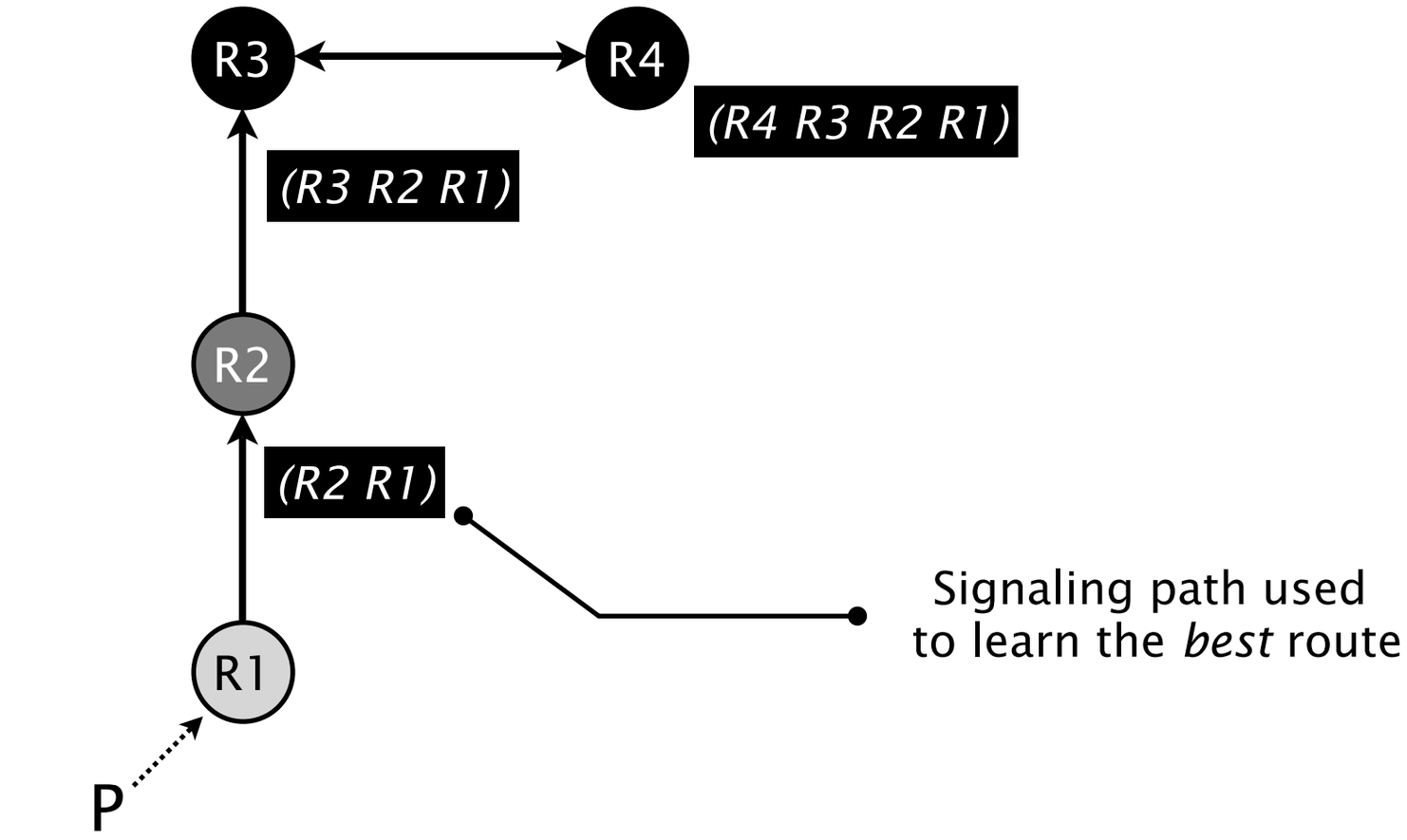
An OVER session between two routers *x* and *y* such that *x* or *y* is not in the RR top layer



Let’s consider a simple example

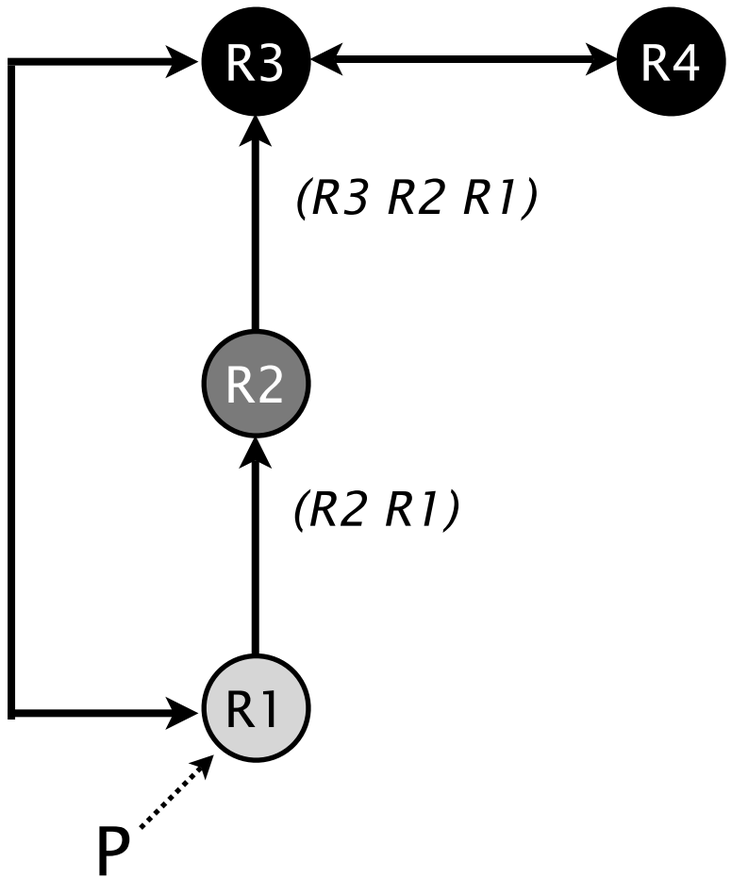


OVER-RIDE GADGET



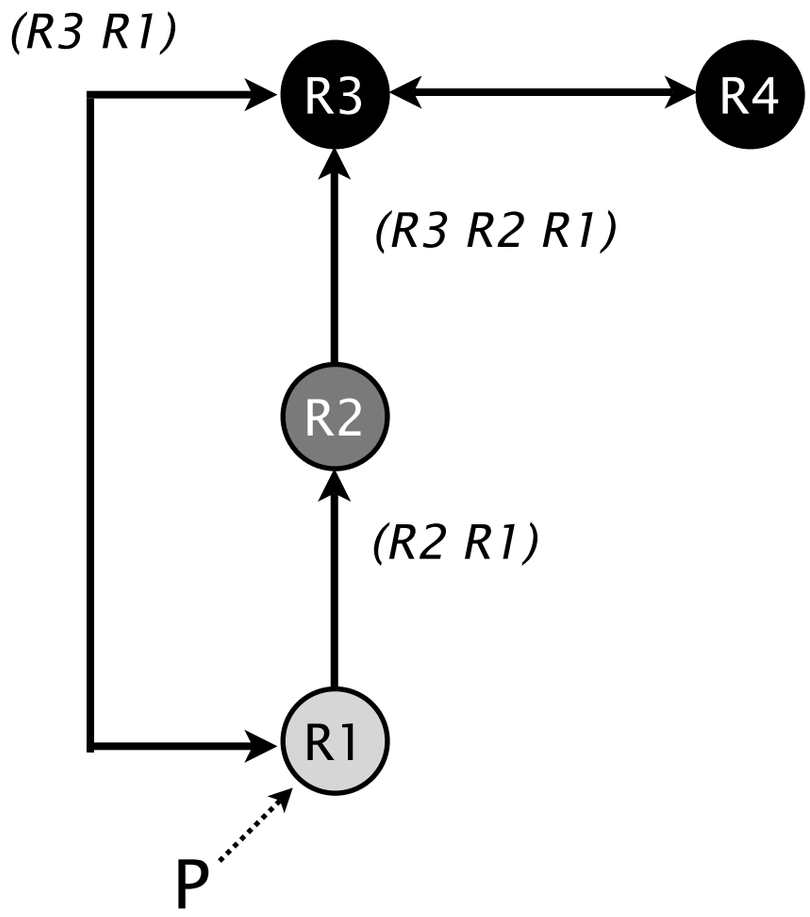
OVER-RIDE GADGET

Let’s add a spurious OVER session between R3 and R1



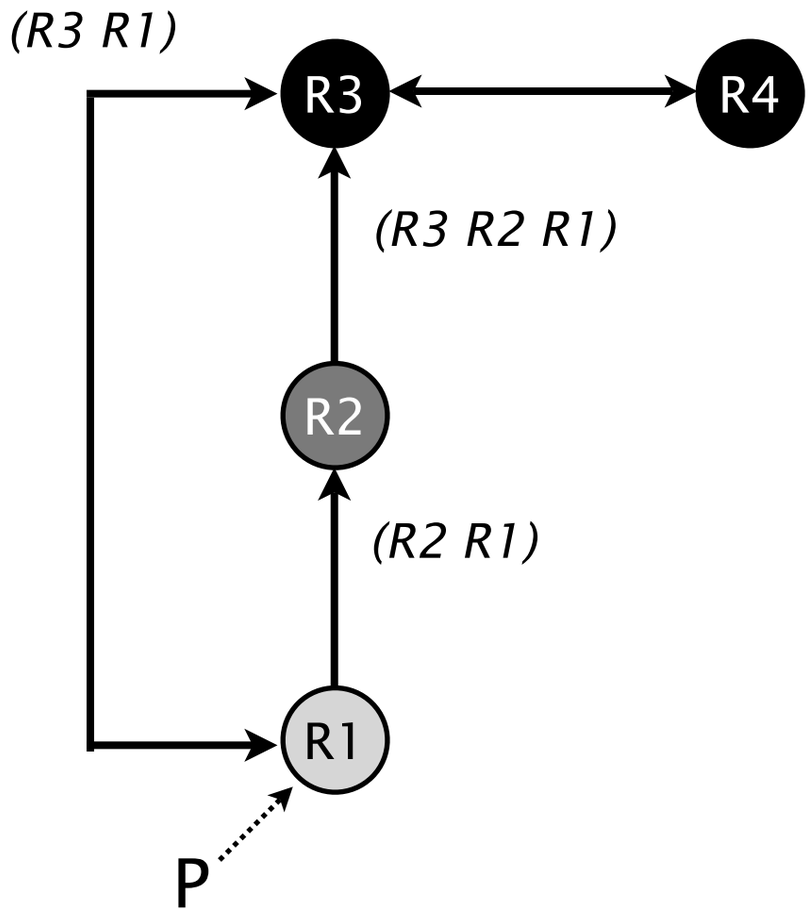
OVER-RIDE GADGET

Now, R3 learns P via two signaling paths



OVER-RIDE GADGET

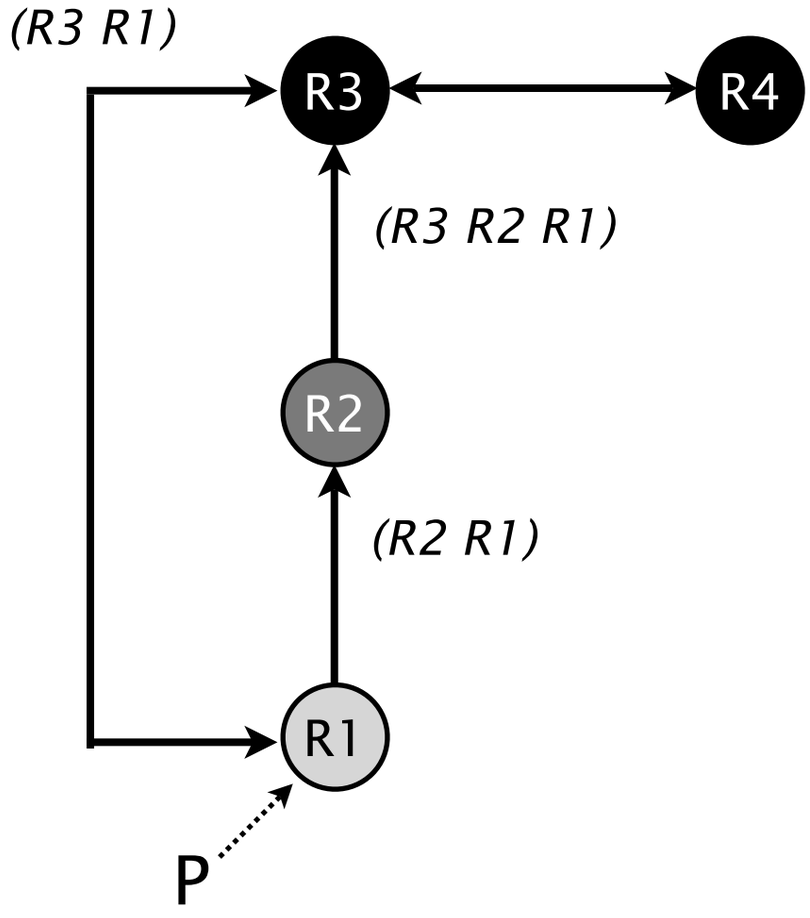
R3 BGP Decision Process is used to select one of them



OVER-RIDE GADGET

BGP Decision Process *(R3 R1)* *(R3 R2 R1)*

1. Higher Local-preference
2. Shorter AS-Path
3. Lower Origin
4. Lower MED
5. Prefer eBGP over iBGP
6. Lower IGP metric to NH
7. Lower Router ID
8. Shorter cluster-list
9. Lower neighbor IP



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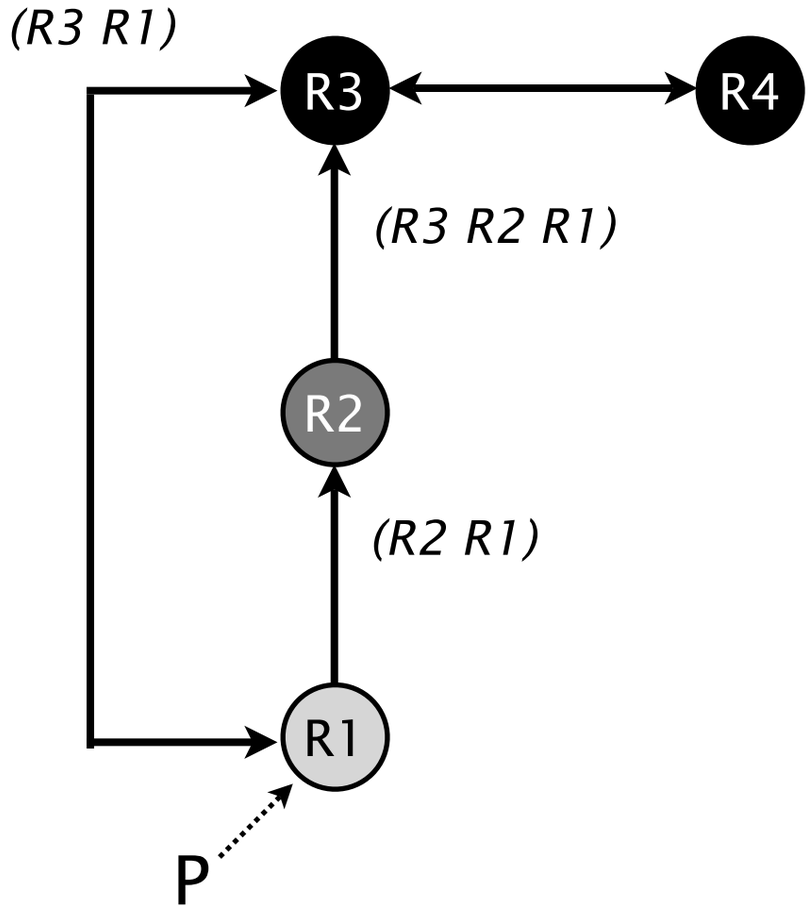

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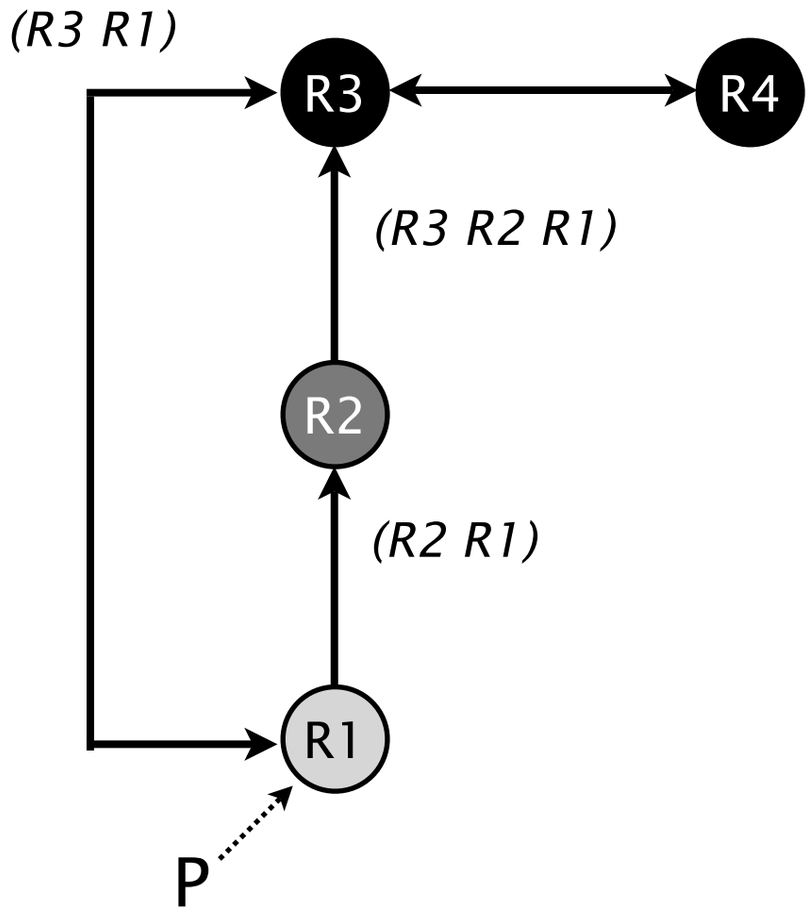

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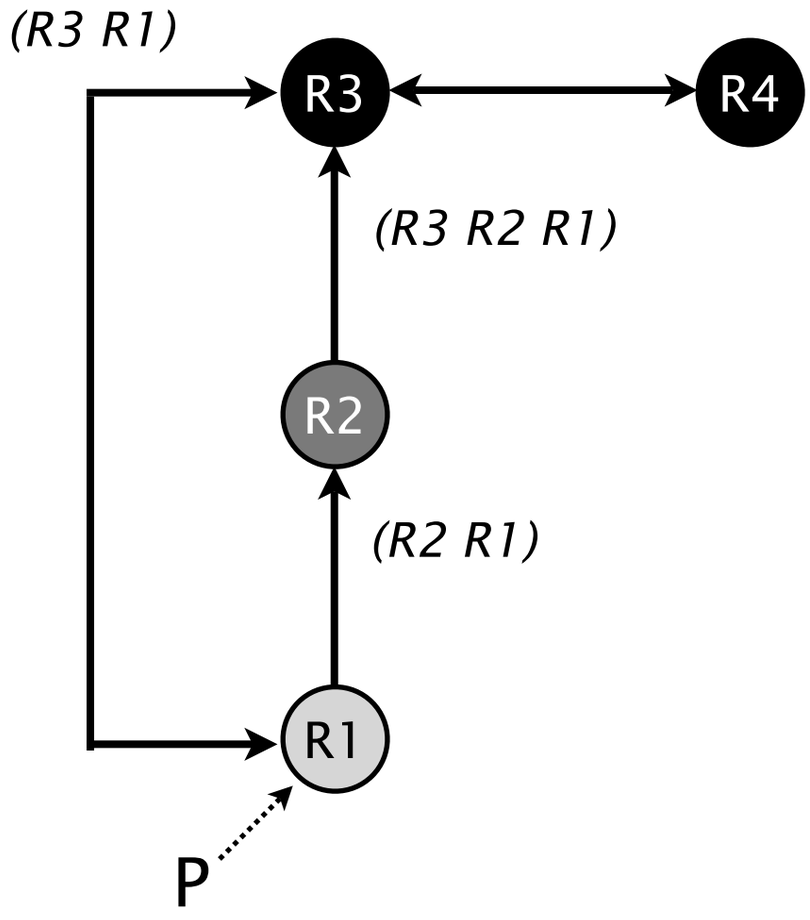
(R3 R1)

(R3 R2 R1)



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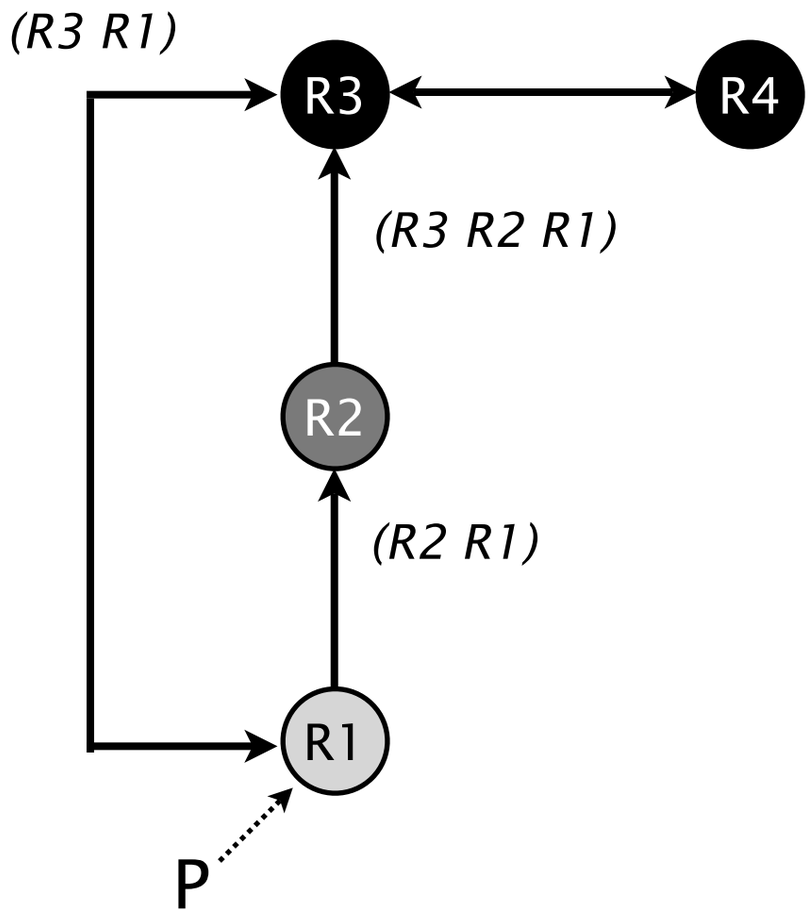

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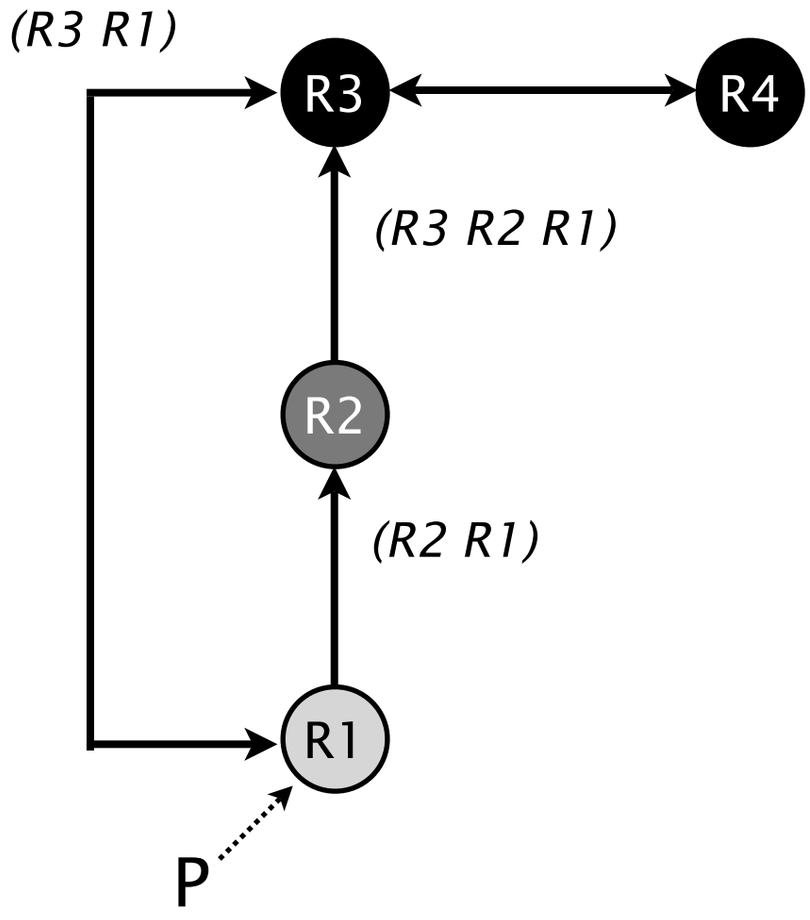

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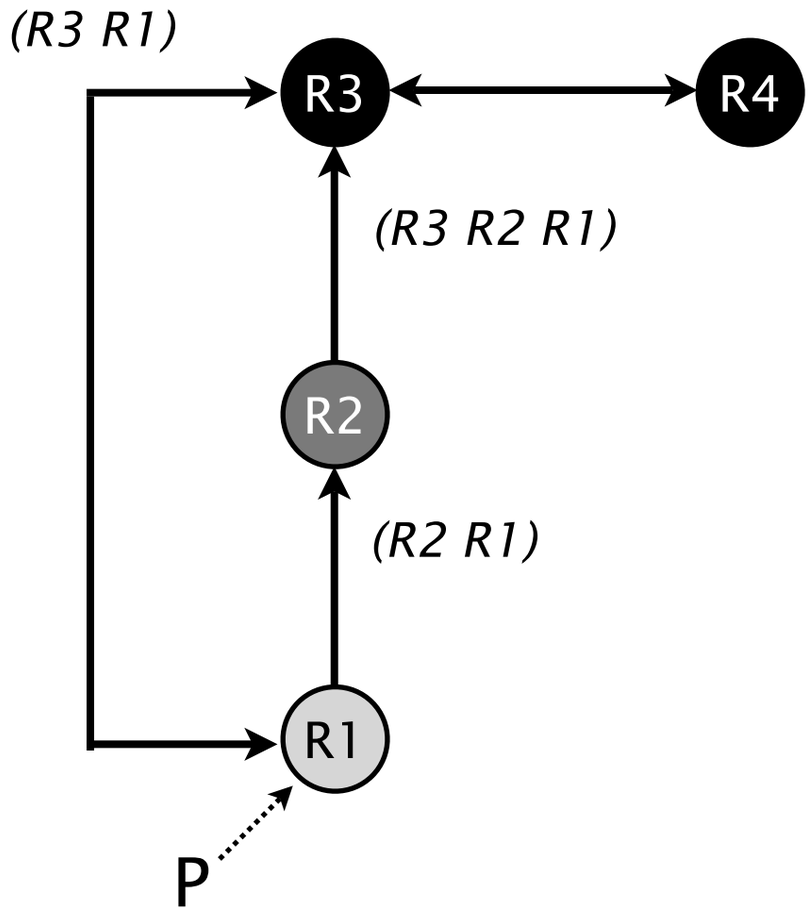

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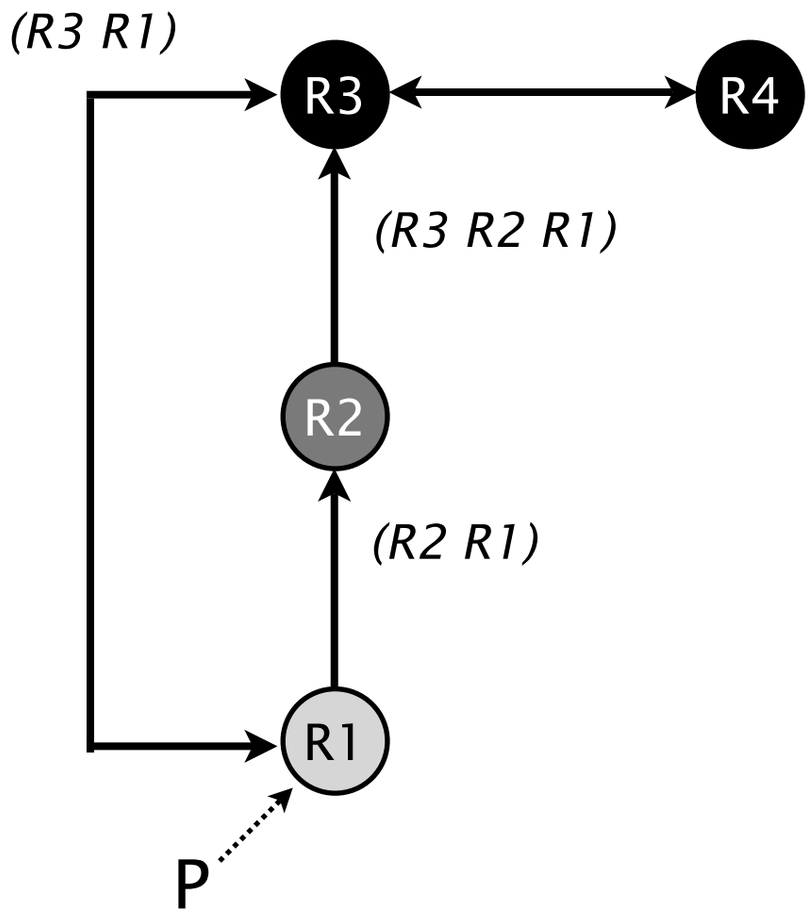
(R3 R1) wins since it has no cluster-list



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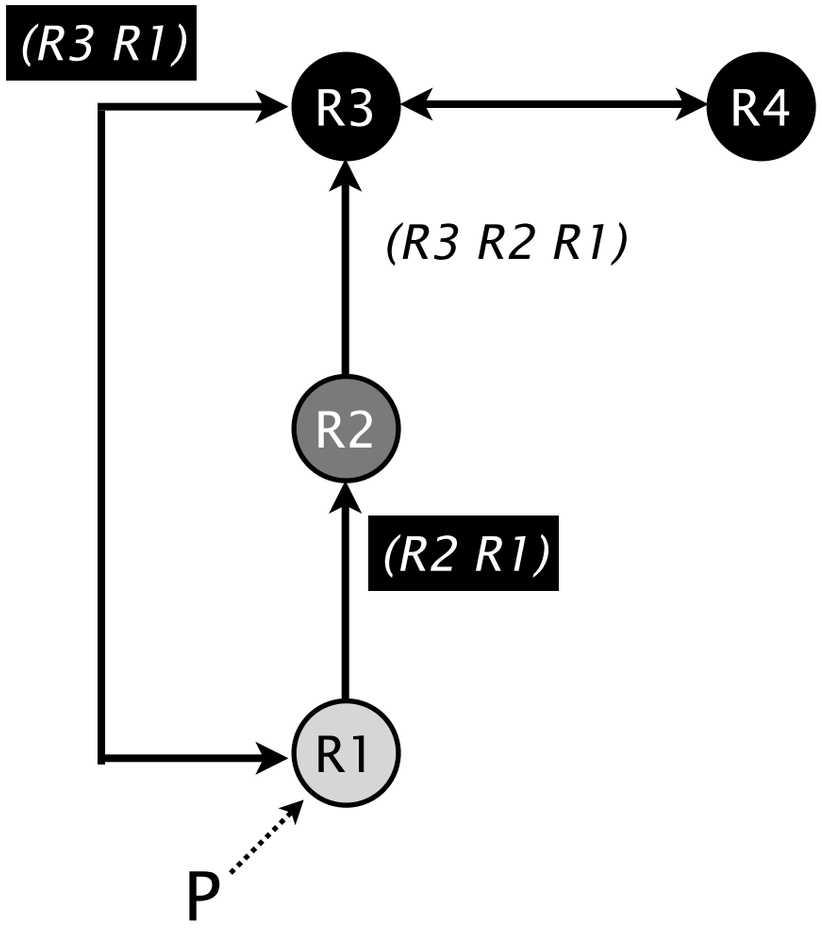
(R3 R1) *(R3 R2 R1)*

↓

wins

Due to BGP Propagation rules,
R3 does not announce the route to R4 anymore

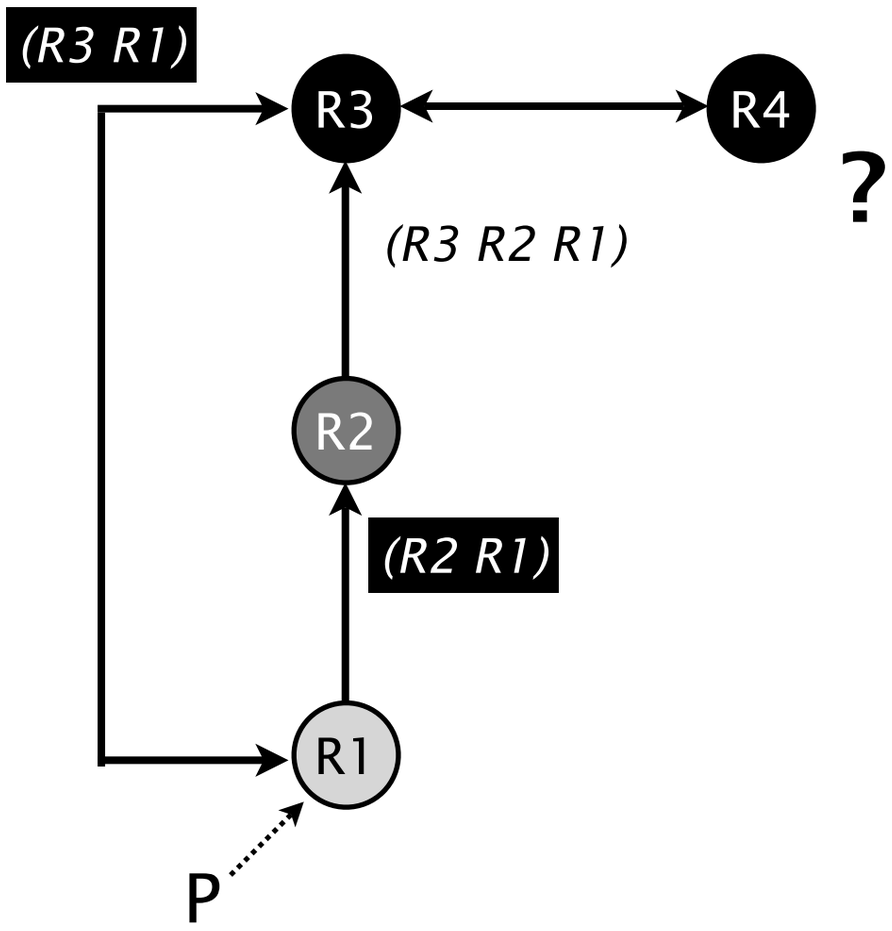


OVER-RIDE GADGET

BGP Propagation rules

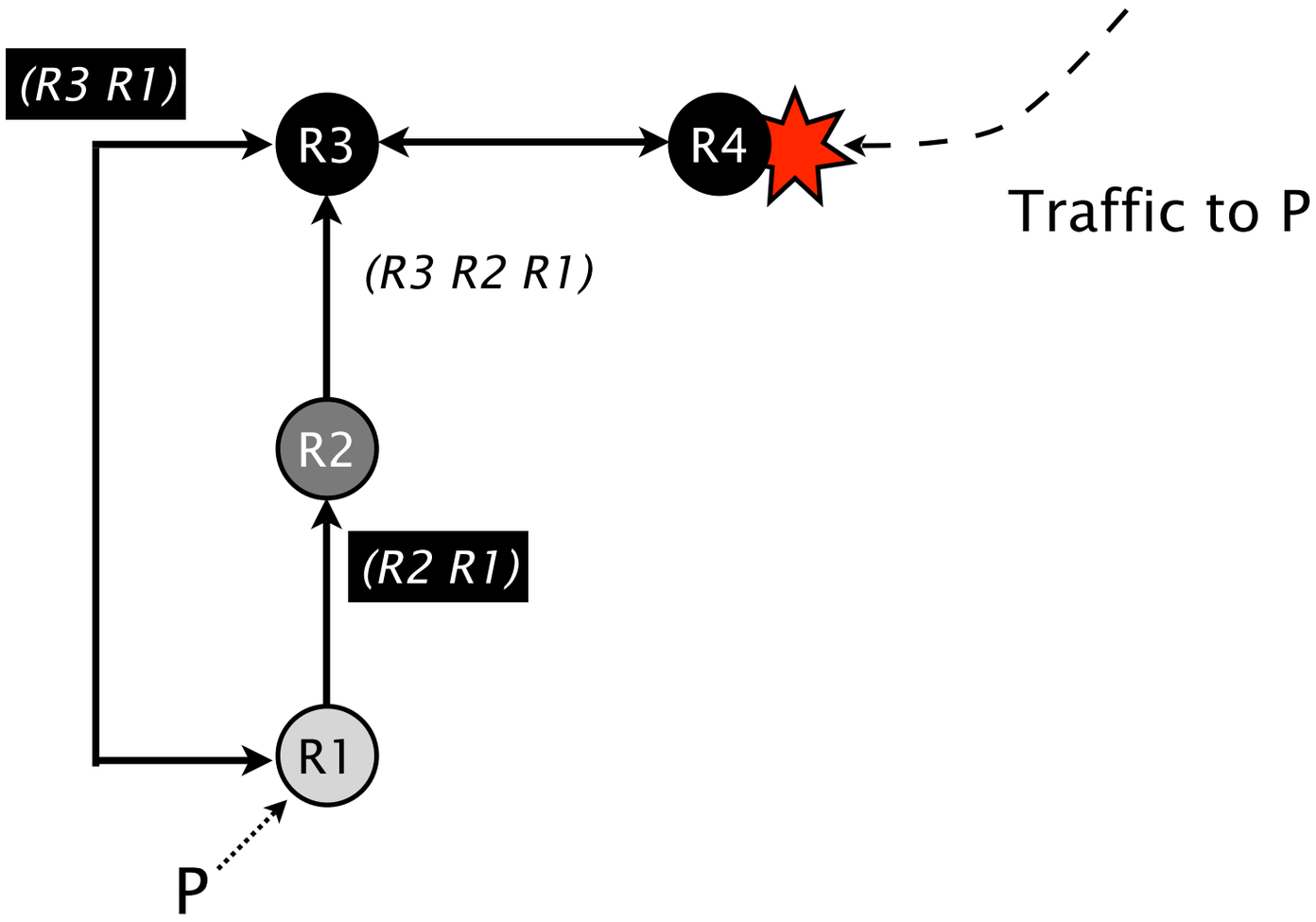
	To client	***To peer***
From client	✓	✓
From peer/RR	✓	×

R4 does not receive any route for P



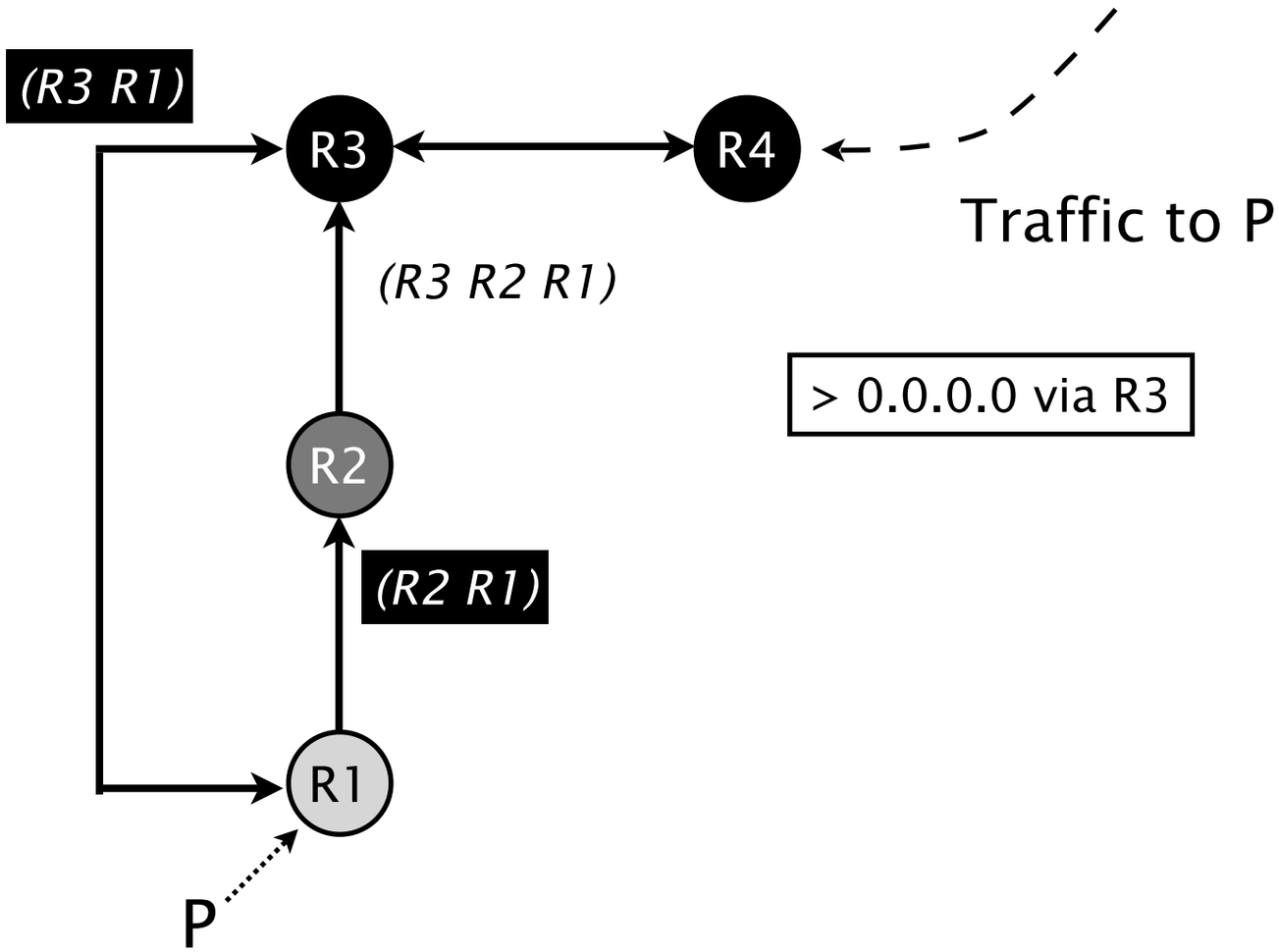
OVER-RIDE GADGET

Either R4 does not learn a less-specific route
and a forwarding blackhole is created



OVER-RIDE GADGET

Or R4 might use a less specific route
which can create forwarding deflections and loops



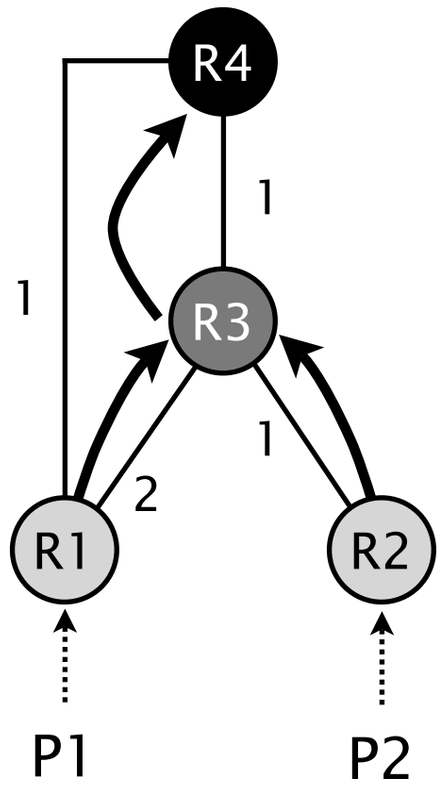
OVER-RIDE GADGET

Although uncommon, spurious OVER might appear in real world network

Spurious OVERs

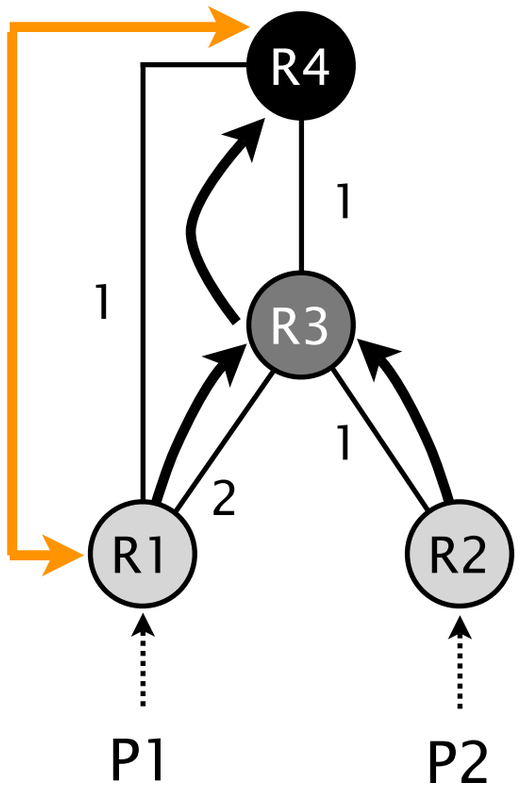
- have been found in real network [Feamster05, Park11]
- act as an easy-visibility fix [Pelsser08, Pelsser10]
- could appear during reconfiguration [Herrero10]

A spurious OVER is an easy and tempting solution to solve route visibility issue



Although preferred, R4 does not receive P1 since R3 prefers P2 (IGP cost), leading to suboptimal routing

A spurious OVER is an easy and tempting solution to solve route visibility issue



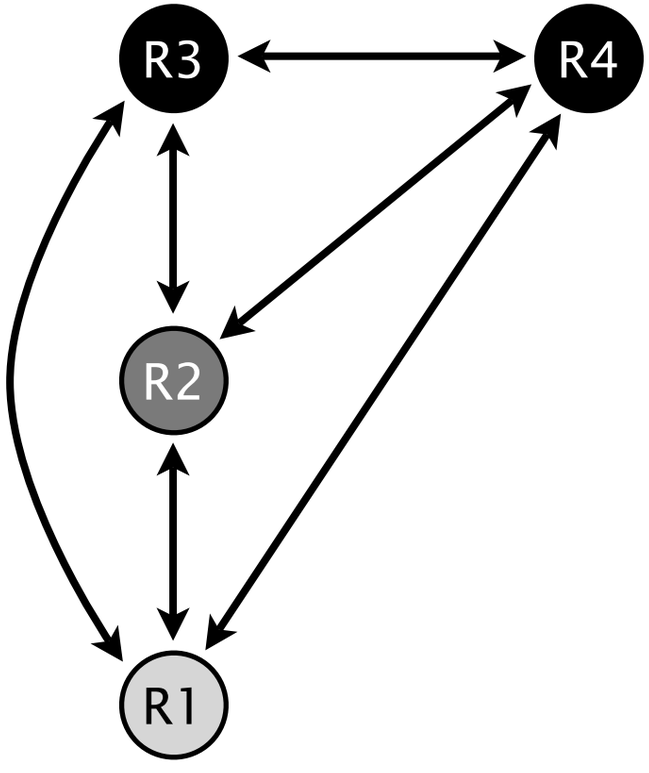
Adding a spurious OVER, improves R3's visibility

[Pelsser08, Pelsser10]

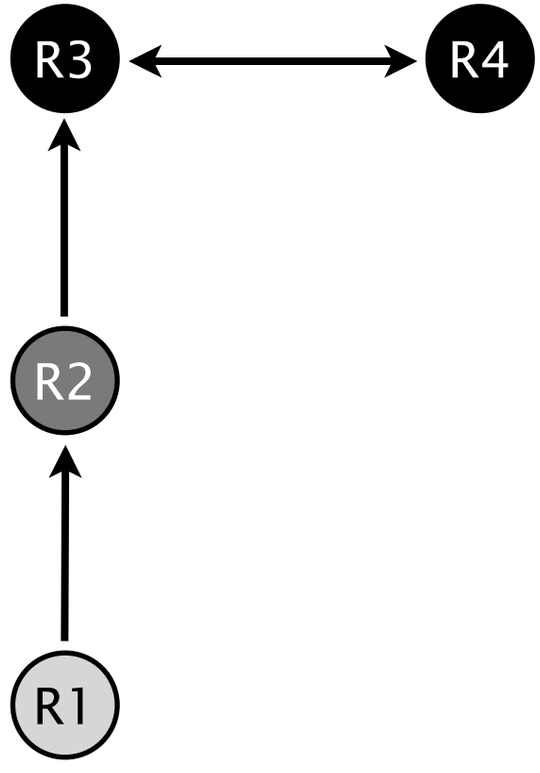
Spurious OVER are likely to appear during iBGP reconfiguration

Best practices: Introduce UPs before tearing OVERs down [Herrero10]

going from



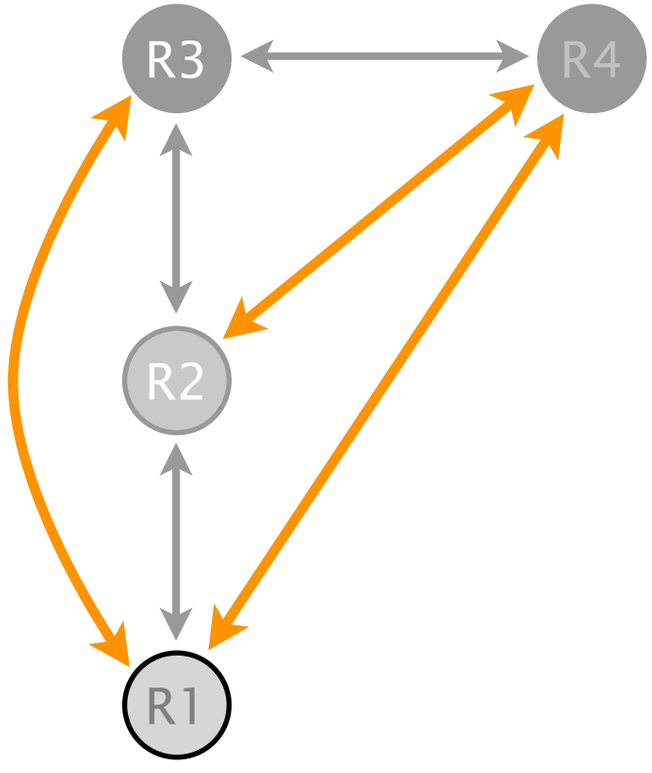
to



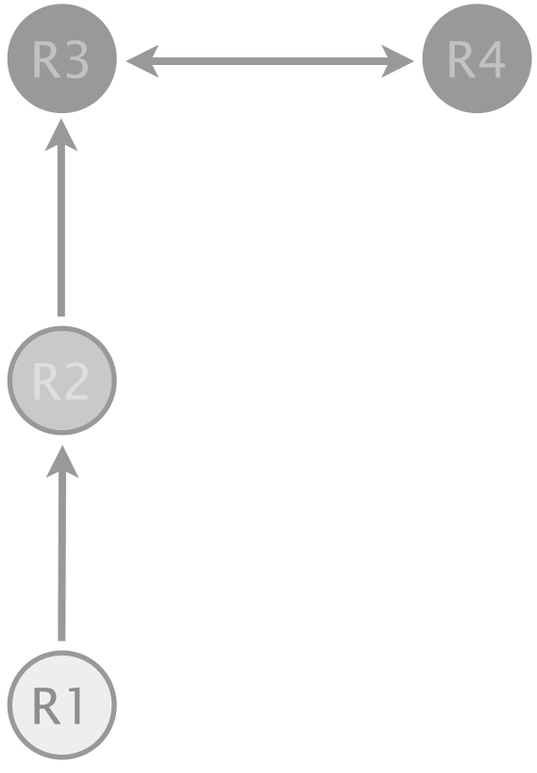
Spurious OVER are likely to appear during iBGP reconfiguration

Best practices: Introduce UP before tearing OVER down [Herrero10] ▶ **potentially spurious OVERs during the process**

going from



to



iBGP Deceptions:
More Sessions, Fewer Routes

Introduction and Motivation

Dissemination correctness

Revisiting the state-of-the-art

Conclusion

Route reflection is prone to both routing and forwarding anomalies

An iBGP configuration is correct if it respects the following two properties [Griffin02]:

- *signaling correctness*
  BGP will always converge to a stable, unique routing state

- *forwarding correctness*
  No forwarding deflection arises along any BGP forwarding path

One property is missing: *dissemination correctness*

An iBGP configuration is correct if it respects the following two properties [Griffin02]:

- *signaling correctness*
  BGP will always converge to a stable, unique routing state

- *forwarding correctness*
  No forwarding deflection arises along any BGP forwarding path

Dissemination correctness deals with issues in the route propagation process

An iBGP configuration is correct if it respects the following **three** properties:

- *signaling correctness*
  BGP will always converge to a stable, unique routing state

- *forwarding correctness*
  Absence of deflection along any BGP forwarding path

- *dissemination correctness*
  all BGP routers are guaranteed to receive a route to all prefixes

Signaling, dissemination and forwarding correctness complement each other

- Signaling correct does not imply dissemination correct

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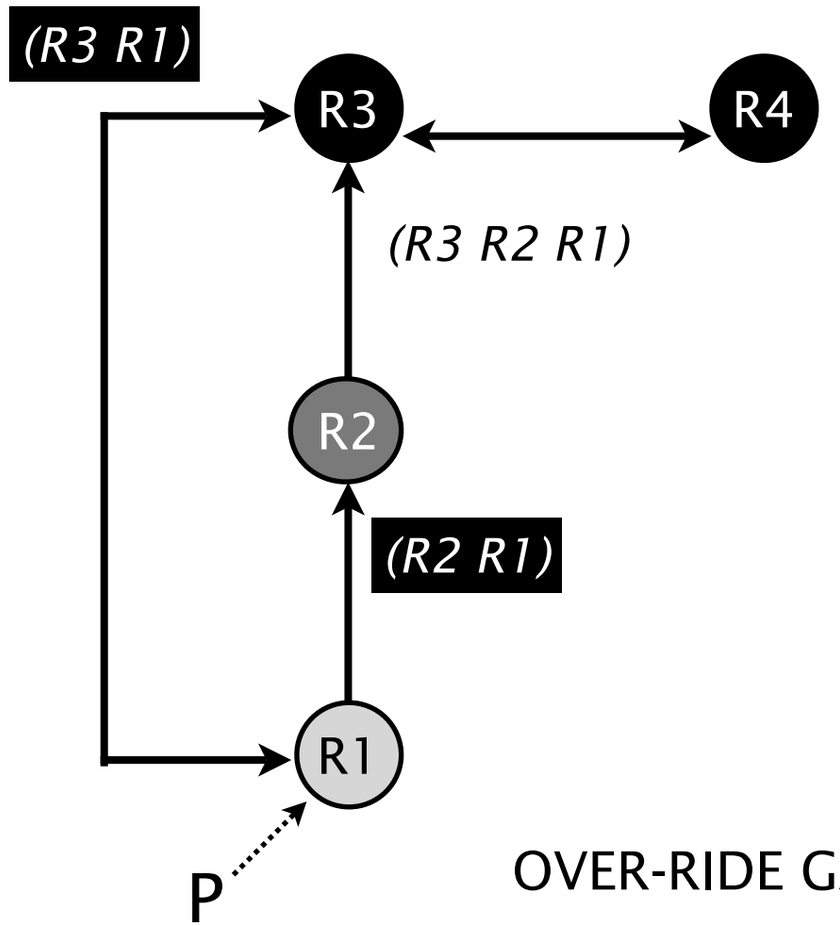
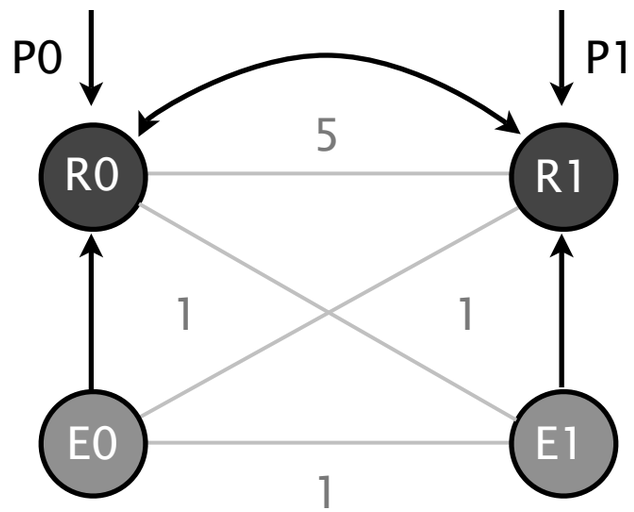


Example of iBGP topology which is *signaling* correct, but not *dissemination* correct

OVER-RIDE GADGET

Signaling, dissemination and forwarding correctness complement each other

- Signaling correct does not imply dissemination correct
- Dissemination correct does not imply forwarding correct



Example of iBGP topology which is *dissemination* correct, but not *forwarding* correct

[Griffin, SIGCOMM02]

Dealing with dissemination correctness is computationally hard

Dissemination Correctness Problem (DCP):

Given a signaling correct iBGP topology *B*
and the underlying IGP topology *I*,

Decide if *B* is dissemination correct

DCP is coNP-hard
P-time reduction from 3-SAT complement

Prior knowledge of correctness is useless

One More Session Problem (OMSP):

Given a dissemination correct iBGP topology *B*,
and the underlying IGP topology *I*,

Decide if adding a spurious OVER session to *B*
will result in a dissemination correct topology

OMSP is coNP-hard
P-time reduction from 3-SAT complement

There exist sufficient conditions that guarantee *dissemination correctness*

Either of the following conditions guarantees a signaling correct iBGP topology to be dissemination correct

- *prefer-client*
  All iBGP routers strictly prefer client routes

- *no-spurious-OVER*
  The iBGP topology contains no spurious OVERs

iBGP Deceptions:
More Sessions, Fewer Routes

Introduction and Motivation

Dissemination correctness

Revisiting the state-of-the-art

Conclusion

Some results already encompass dissemination correctness

Sufficient conditions guaranteeing signaling, forwarding correctness

On the correctness of IBGP configuration [Griffin, SIGCOMM02]

Some results already encompass dissemination correctness

Sufficient conditions guaranteeing signaling, forwarding correctness

On the correctness of IBGP configuration [Griffin, SIGCOMM02]

i) *B* has no cycles of UP sessions only
ii) **Route-reflector prefers paths propagated by clients**
iii) All-shortest-paths must also be valid signaling paths

implies dissemination correctness

Dissemination is often overlooked

Relaxed sufficient conditions for signaling or forwarding correctness

Preventing persistent oscillations and loops
in IBGP configuration with route reflection [Rawat, Comput.Netw.06]

Checking for optimal egress points in iBGP routing [Buob, DRCN07]

[Buob, Networking08]

Such conditions do not imply
dissemination correctness
(e.g. OVER-RIDE gadget)

Dissemination is often overlooked

Guarantee iBGP convergence by modifying the decision process

Stable and flexible iBGP [Flavel, SIGCOMM09]

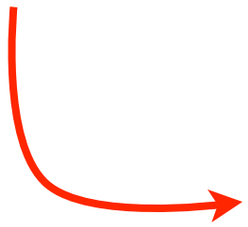
Modified iBGP does not guarantee dissemination (e.g., OVER-RIDE gadget)

Dissemination is often overlooked

Improve route diversity by adding spurious OVERs

Improving route diversity through the design of iBGP topologies [Pelsser, ICC08]

Providing scalable NH-diverse iBGP route redistribution to achieve sub-second switch-over time [Pelsser, Comput. Netw.10]



adding spurious OVERs increase the diversity only *locally*, but may worsen it *globally*

Dissemination is often overlooked

iBGP topology design guidelines

How to Construct a Correct and Scalable iBGP Configuration [Vutukuru, INFOCOM06]

> Lemma 3
>
> "If there exists a signaling chain between routers *A* and *B* [...] then A learns of the best route via B [...]"

Not true in presence of spurious OVERs

Having a valid signaling path is *necessary, not sufficient*

Summary of our contributions

In this work, we

- showed that iBGP Propagation rules play a big role in iBGP
- introduced dissemination correctness
  - studied its complexity
  - provided sufficient conditions and guidelines to enforce it
- showed that dissemination is often overlooked

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iBGP semantic is more complex than what is commonly assumed

- Valid signaling path is not a good abstraction to study route propagation

- Spurious OVERs invalidate assumptions that apparently hold in any iBGP topology

- Dissemination correctness provides new motivations for decoupling route *propagation* from route *selection*

iBGP Deceptions: More Sessions, Fewer Routes

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