[OSPF Goodies for ISPs](#)

North American Network Operators Group (NANOG)

October 1999 meeting

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The Past

- **Version 1**
  - **RFC 1131 IETF Proposed Standard**
- **Version 2**
  - **RFC 1247 IETF Proposed Standard**
  - **RFC 1583 IETF Draft Standard**
- **RFC 1812 requires OSPF for dynamic routing**
- **And things progressed...**

The Near Term

- **RFC 2178**
  - **Still at Draft Standard level; still Version 2**
  - **Enhancements**
    - **NSSA**
    - **Demand Circuits**
    - **OSPF over Frame**
    - **Cryptographic authentication**
  - **TOS routing removed**
- **RFC 2328**
  - **Full Standard**

The Standards Future

- ## OSPF Version 6
  - Originally intended for V6 only
  - Made dual capable for V4 and V6, and possibly other protocols such as IPX
  - Generally upward compatible
    - better scalability for Multicast OSPF
    - quality of service routing
  - Internet Draft

OSPF and Single Areas

An Area has...

- **Am area ID**
- **A set of address prefixes**
  - Do not have to be contiguous
  - So a prefix can be in only one area
- **A set of router IDs**
  - Router functions may be interior, inter-area, or external

Areas and Performance

- **General workload for routing:**

  $O(\text{Prefixes})$

- **In general area$_k$ structure, workload per router:**

  $O(\text{Prefixes}_k +$

  $\text{InjectedExternals}_k)$

  $O(x)$: "on the order of x"

- **In OSPF area$_k$, workload per router:**

  $O((\text{Prefixes}_k +$

  $\text{InjectedExternals}_k)) +$

  $\log(\text{Routers}_k)$

Area Sizing Guidelines

- **Rules of thumb for non-backbone area**
  - No more than 100 routers
  - No more than 50 neighbors per router
- **Decrease when media unstable**
  - Consider static/default and demand techniques
- **Decrease when large numbers of externals injected**
  - Consider if the incoming externals can be summarized or filtered

When Might Single-Area OSPF make sense?

- **Fewer than 50 routers with alternate paths**
- **Needs:**
  - multivendor compatibily
  - fast convergence
  - VLSM
  - complex defaults and externals
- **No clear candidates for core**
  - OSPF power greatest with hierarchy
  - Multiple domains may be better than 1 area
  - EIGRP a possible alternative

How Many Areas?

- **Map communities of interest (COI) to areas**
- **Add COI until number of routers exceeded**
- **Avoid >2-3 areas per ABR unless very stable**
- **Watch CPU loading in ABRs**
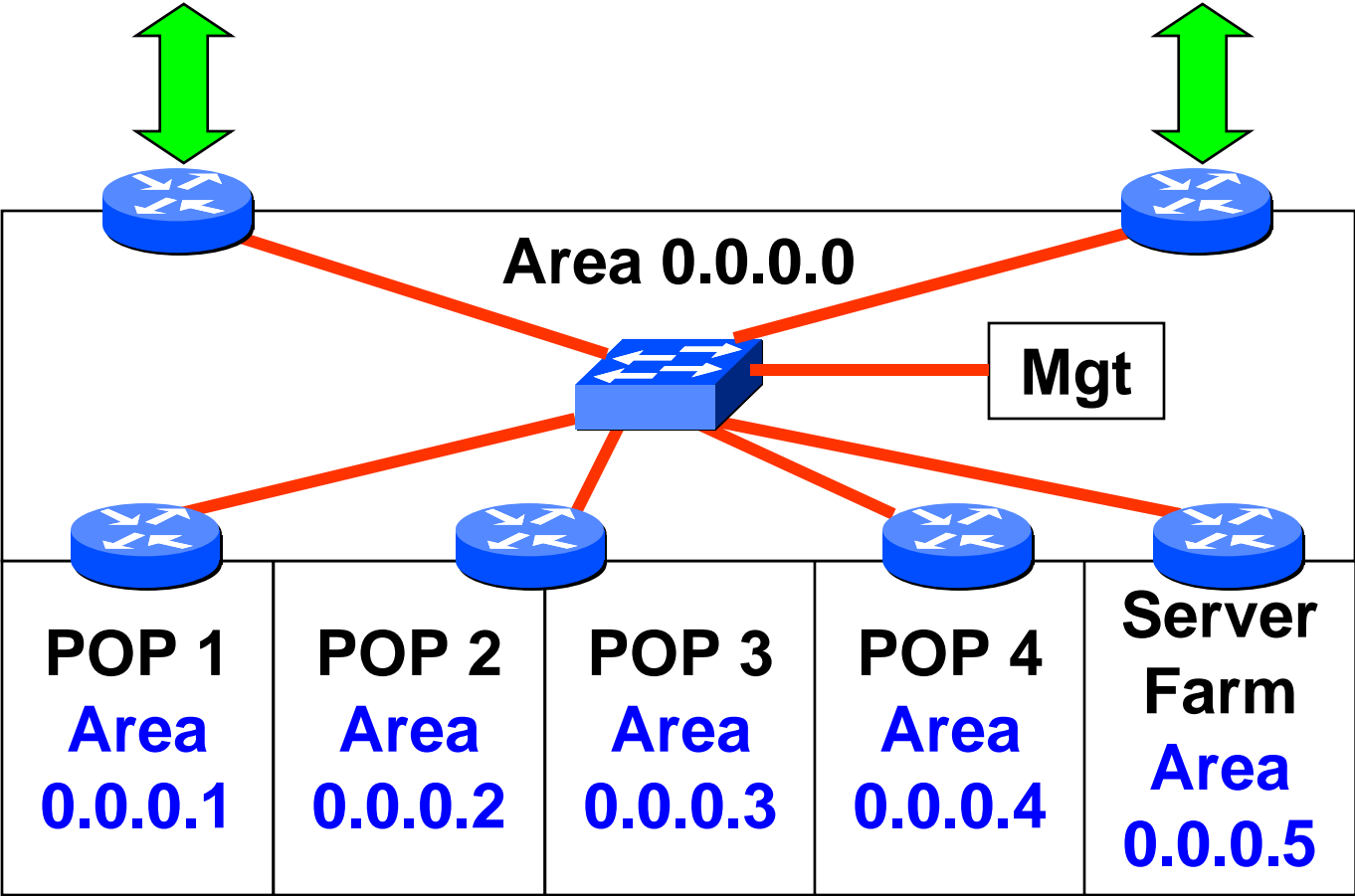- **Numbering easier if #areas is power of 2**
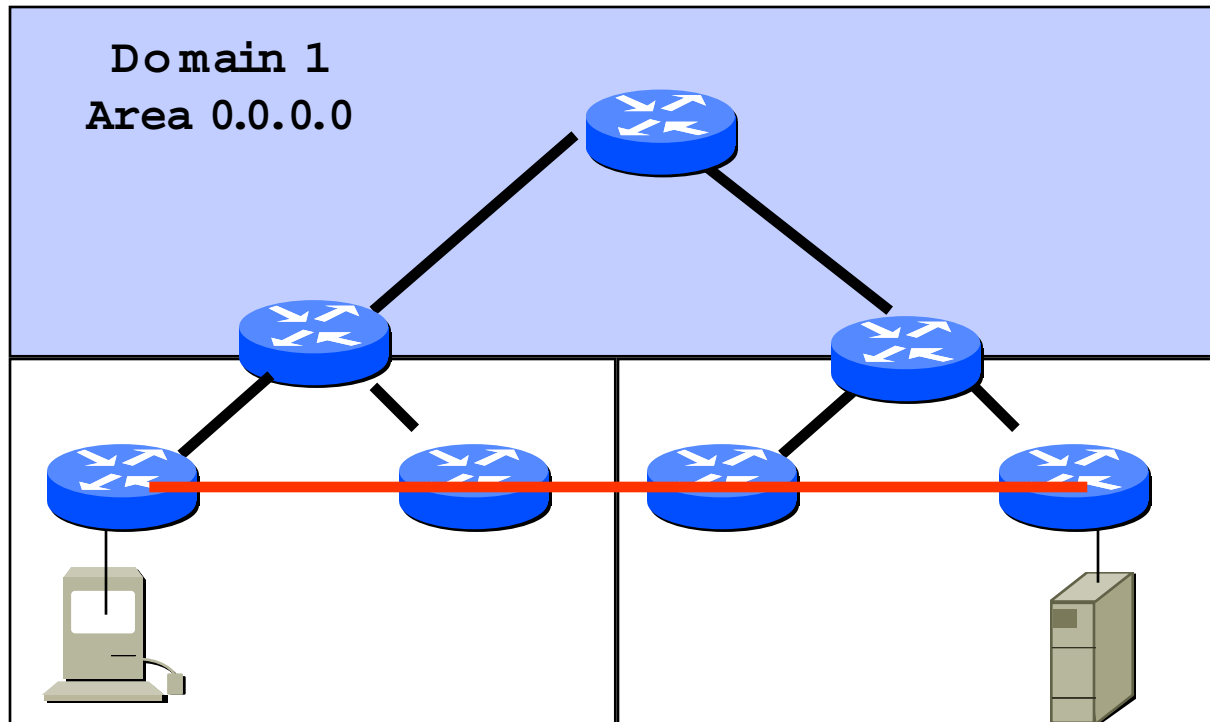
SIngle-Domain Inter-Area

Basic Inter-Area

Area 0.0.0.0

Area 0.0.0.1

Area 0.0.0.2

Area 0.0.0.3
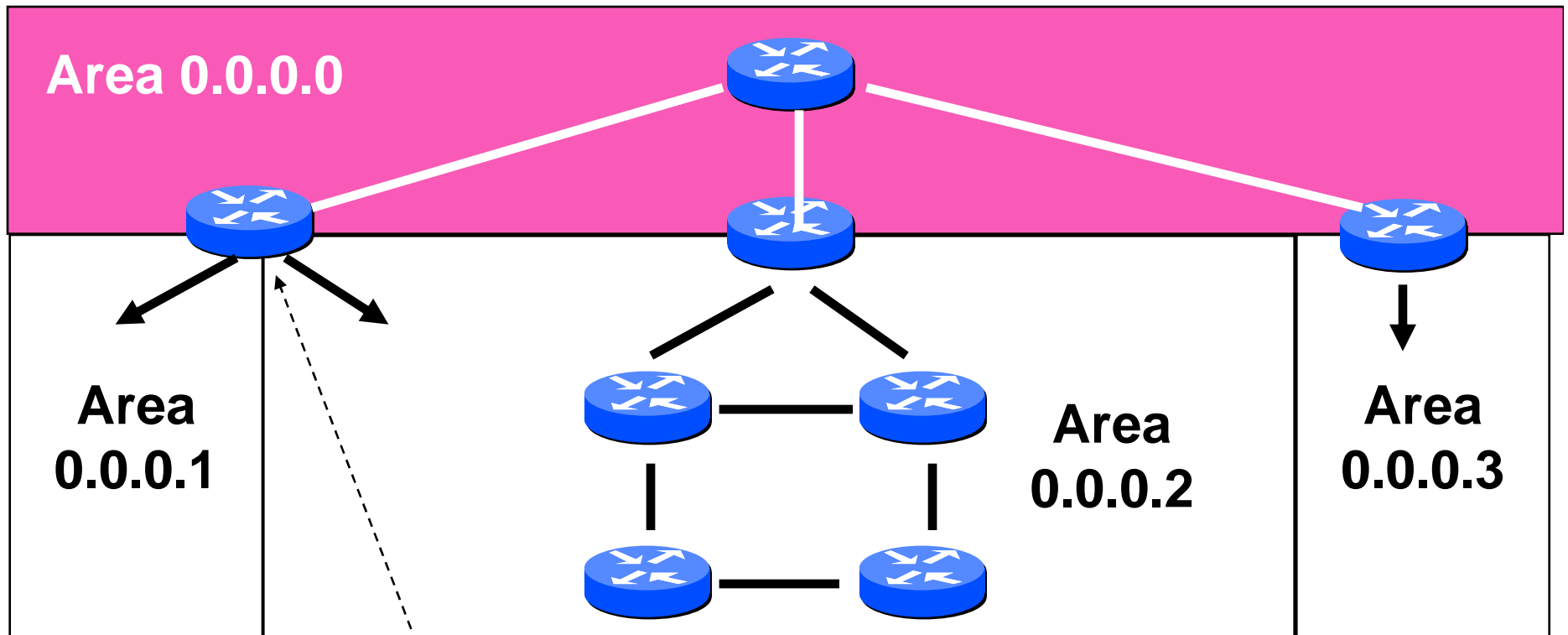
Note ABR servicing multiple nonzero areas.
Rule of thumb -- not more than 3 nonzero areas

ISP OSPF 1: Implementation

Area 0.0.0.0

Mgt

POP 1	POP 2	POP 3	POP 4	Server Farm
Area 0.0.0.1	Area 0.0.0.2	Area 0.0.0.3	Area 0.0.0.4	Area 0.0.0.5

The Right Reason to Break Hierarchy
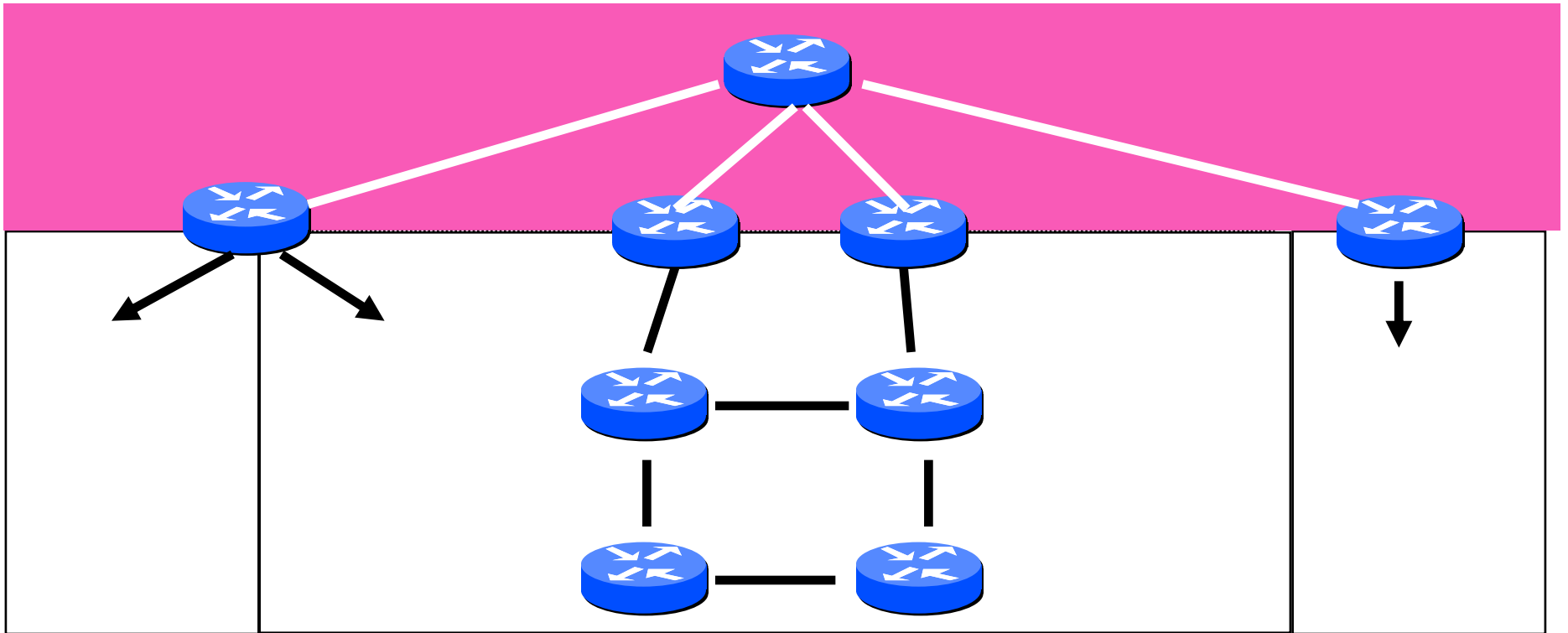# Traffic management, not "redundancy"

Domain 1
Area 0.0.0.0

—— OSPF flow for general traffic and backup

—— Static route with AD < 110 for heavy traffic

Summarization/Aggregation

- ## Summarization
  - Reduces inter-area route workload
  - Configure manually on ABR

- ## Aggregation
  - Reduces external route workload
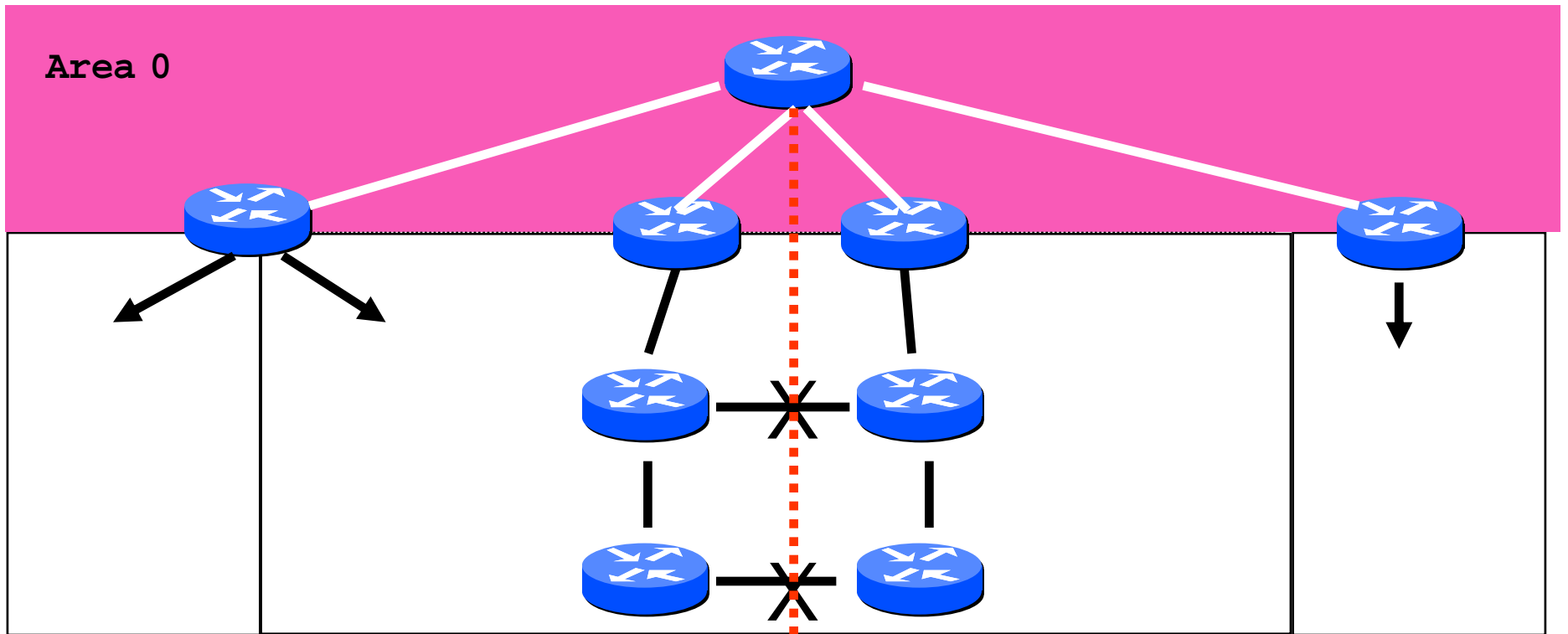 - Configure manually on ASBR
  - Complements stubby areas

Multiple ABR

Both ABRs advertise the same summary when summarization is configured
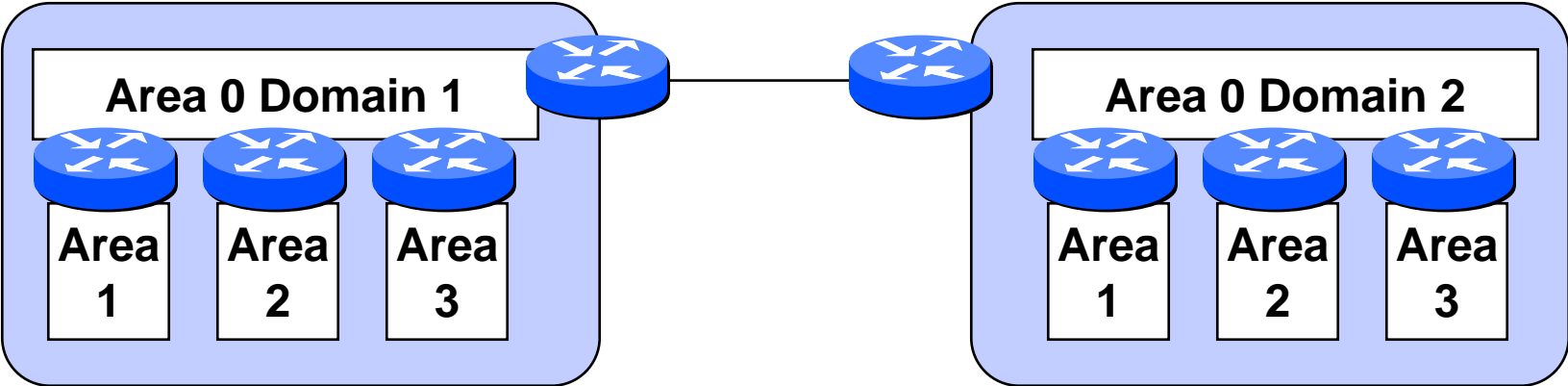
Partitioned Nonzero Areas

Area 0

Both ABRs still advertise the same summary when summarization is configured. Ooops!

External Information
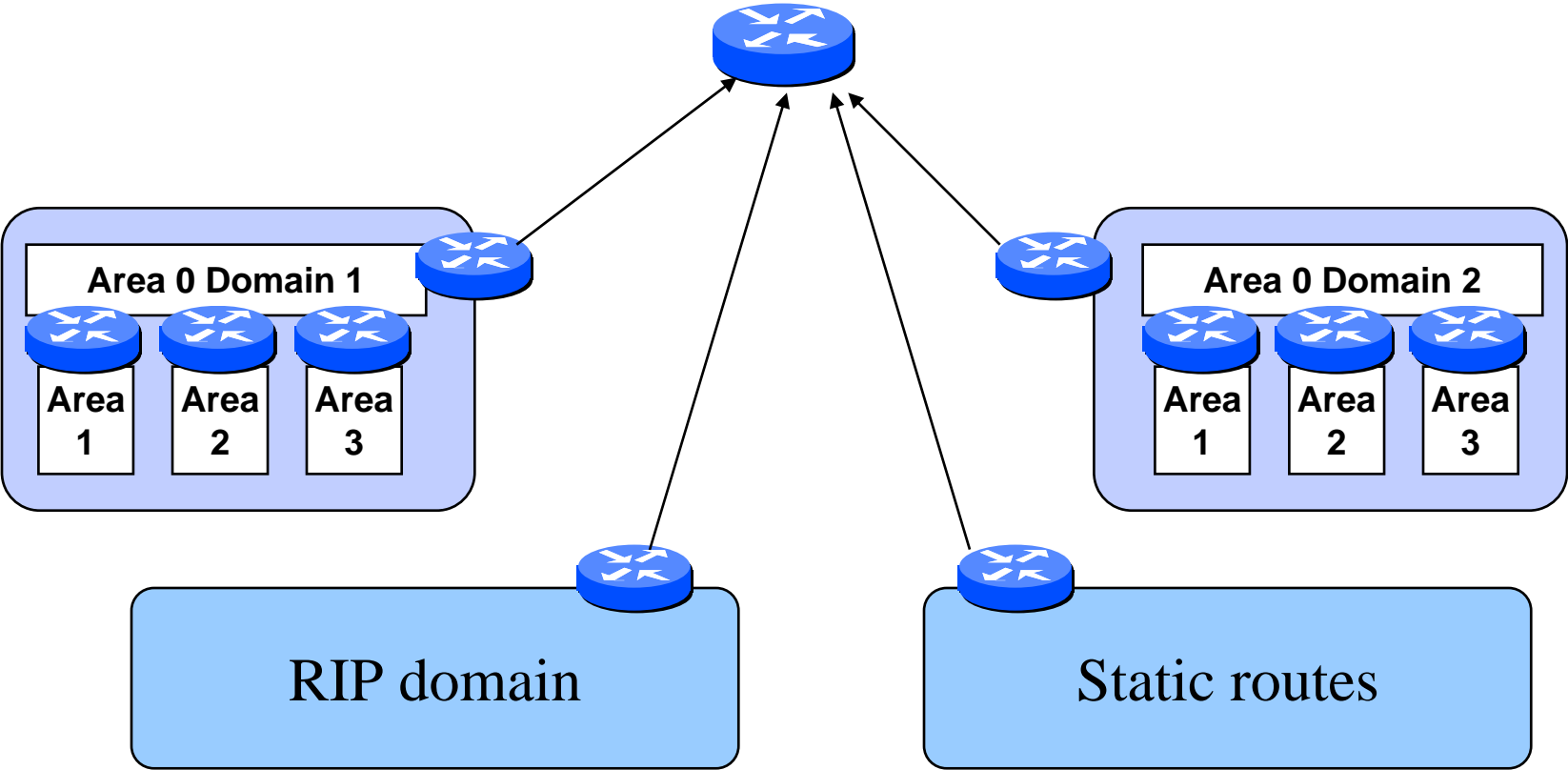
Externals are a Good Thing

- **A way to learn about things outside your local system**
- **Allow workarounds to some awkward configurations**
- **Sources of externals include:**
  - **Other OSPF domains**
  - **Other IGPs: EIGRP, IGRP, RIP, IS-IS**
  - **BGP-4**
  - **Static routes**
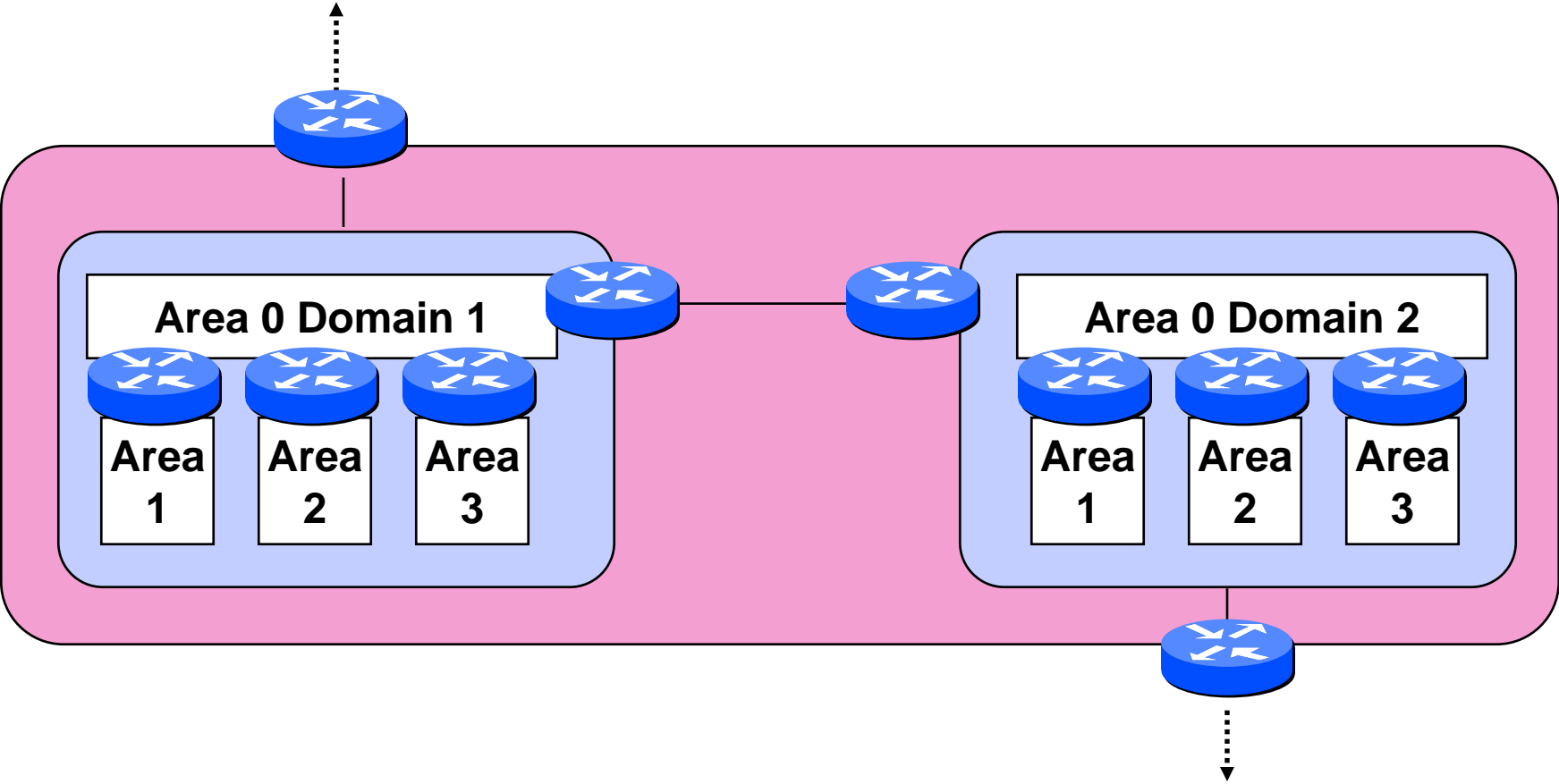
Multiple Homogeneous Domains

Area 0 Domain 1				Area 0 Domain 2		
Area 1	Area 2	Area 3		Area 1	Area 2	Area 3

Multiple OSPF copies with different process ID

Multiple Heterogeneous Domains

Area 0 Domain 1

| Area 1 | Area 2 | Area 3 |

Area 0 Domain 2

| Area 1 | Area 2 | Area 3 |

RIP domain

Static routes

Note hierarchy!

Multiple Autonomous Systems

Area 0 Domain 1

| Area 1 | Area 2 | Area 3 |

Area 0 Domain 2

| Area 1 | Area 2 | Area 3 |

BGP becomes involved

Externals and Aggregation 1

- **A full ISP routing table has approximately 62,000 routes**
  - **But will you do anything differently if you know all of them and have a single ISP?**
  - **Multiple ISP situations call for complex OSPF and BGP design**
- **Never redistribute IGPs into BGP**
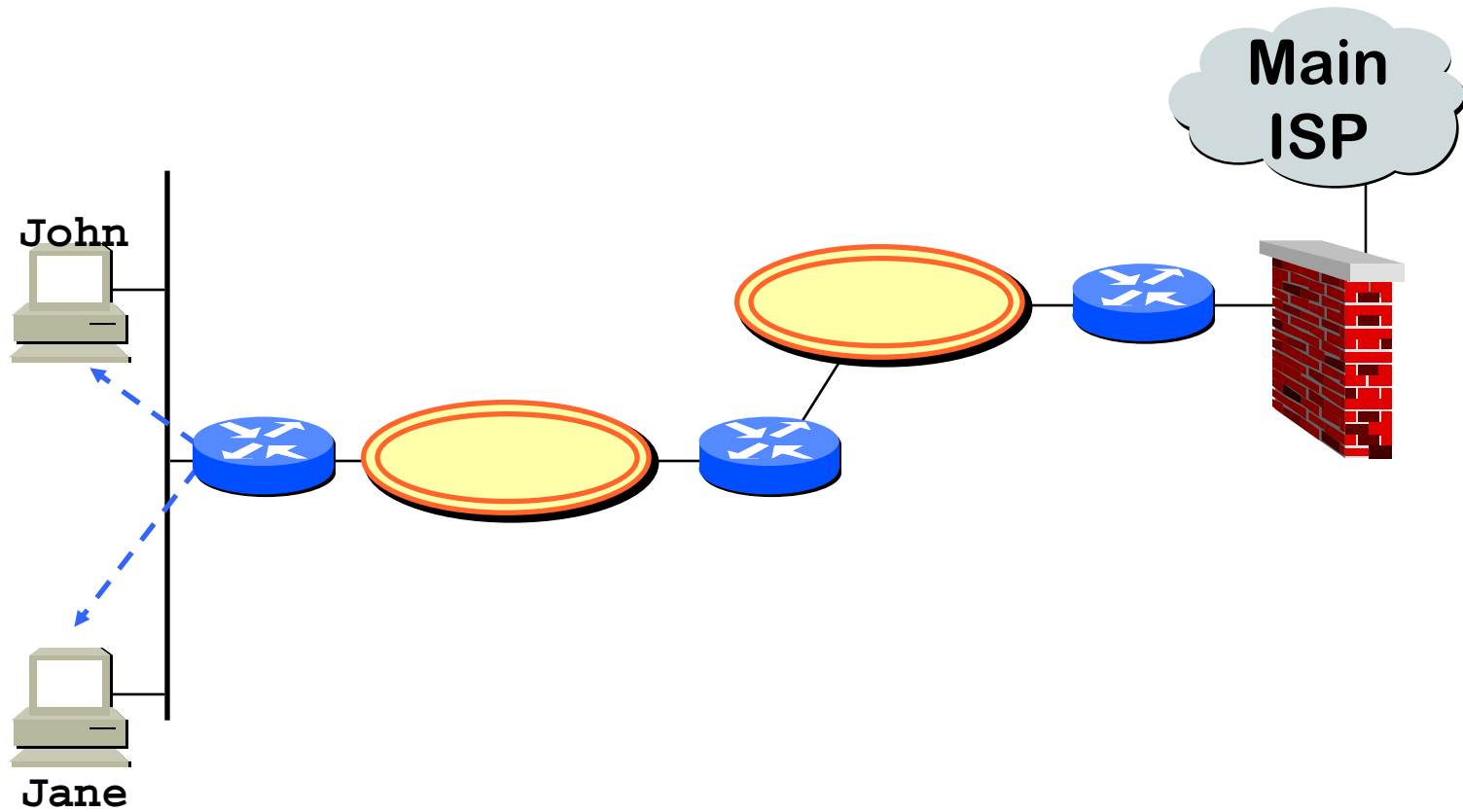- **Restribute BGP into IGPs with extreme care**

Question:

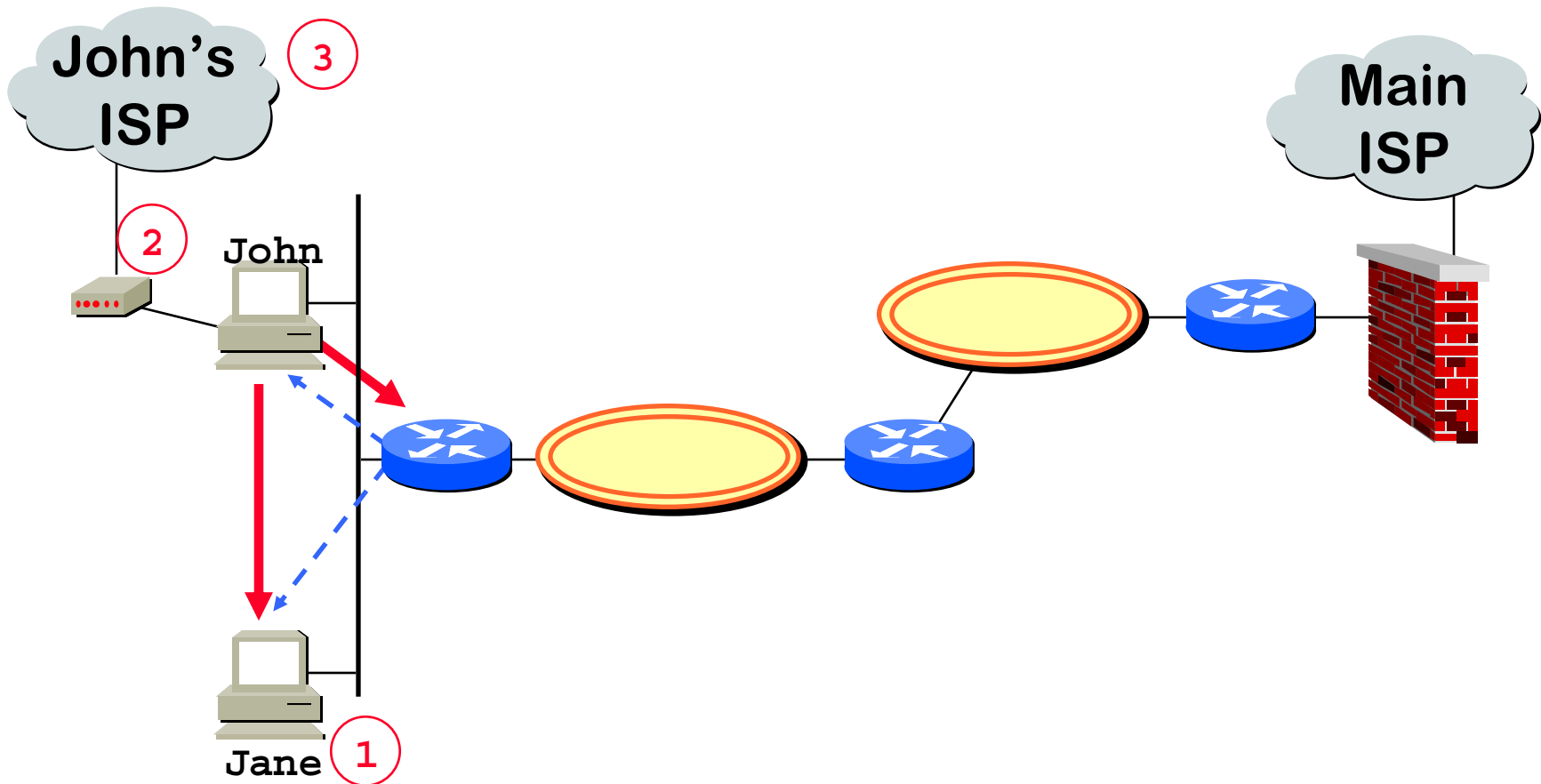## How many of your customers expect "automagic" configuration?

- **[Customer Advertising to You with Interior Routing Protocol](#)**

- **Generally not a good idea**
- **If you <u>must</u>, OSPF, EIGRP, IS-IS probably safer**
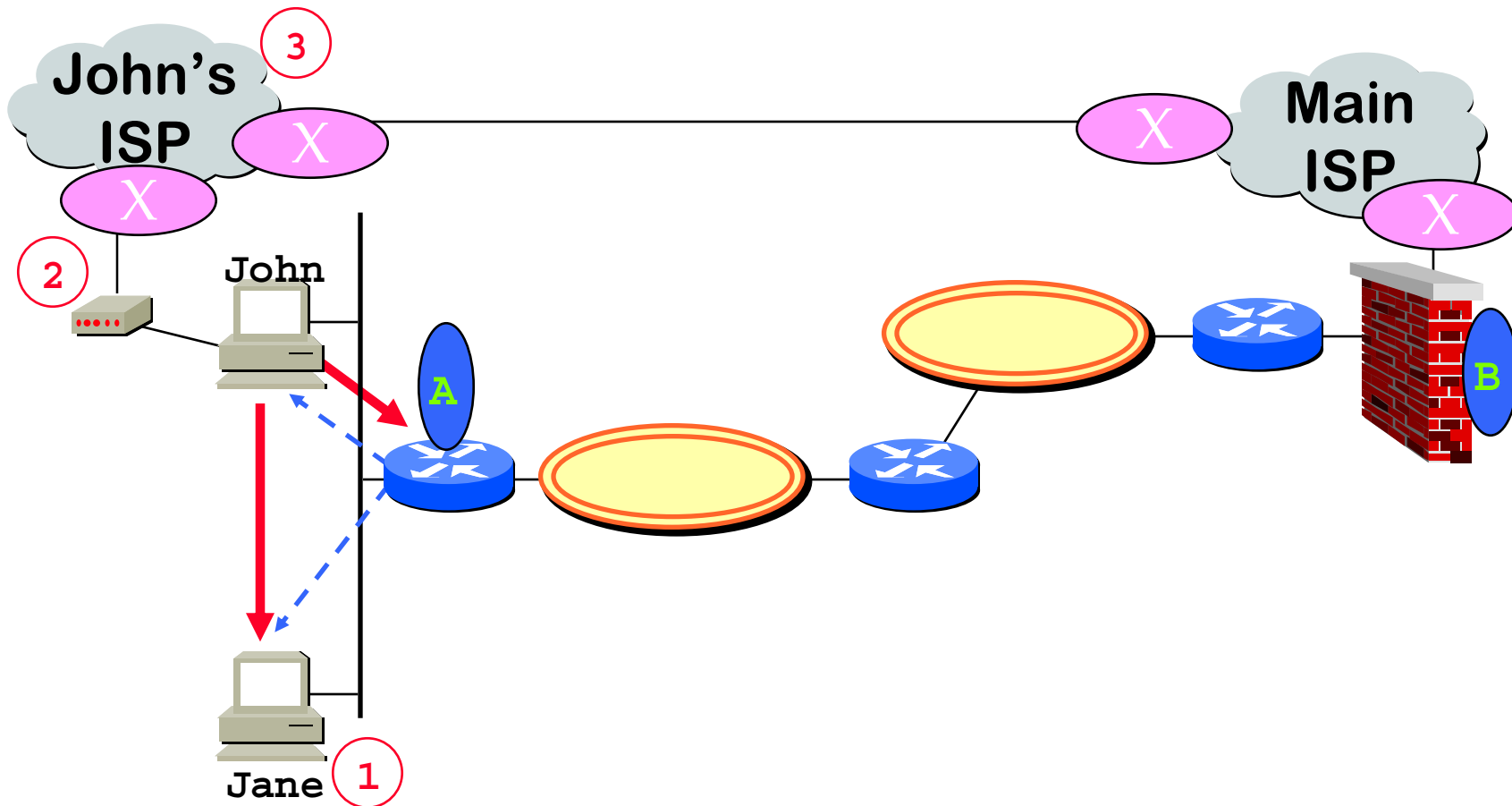 - **RIP has too many leak risks**
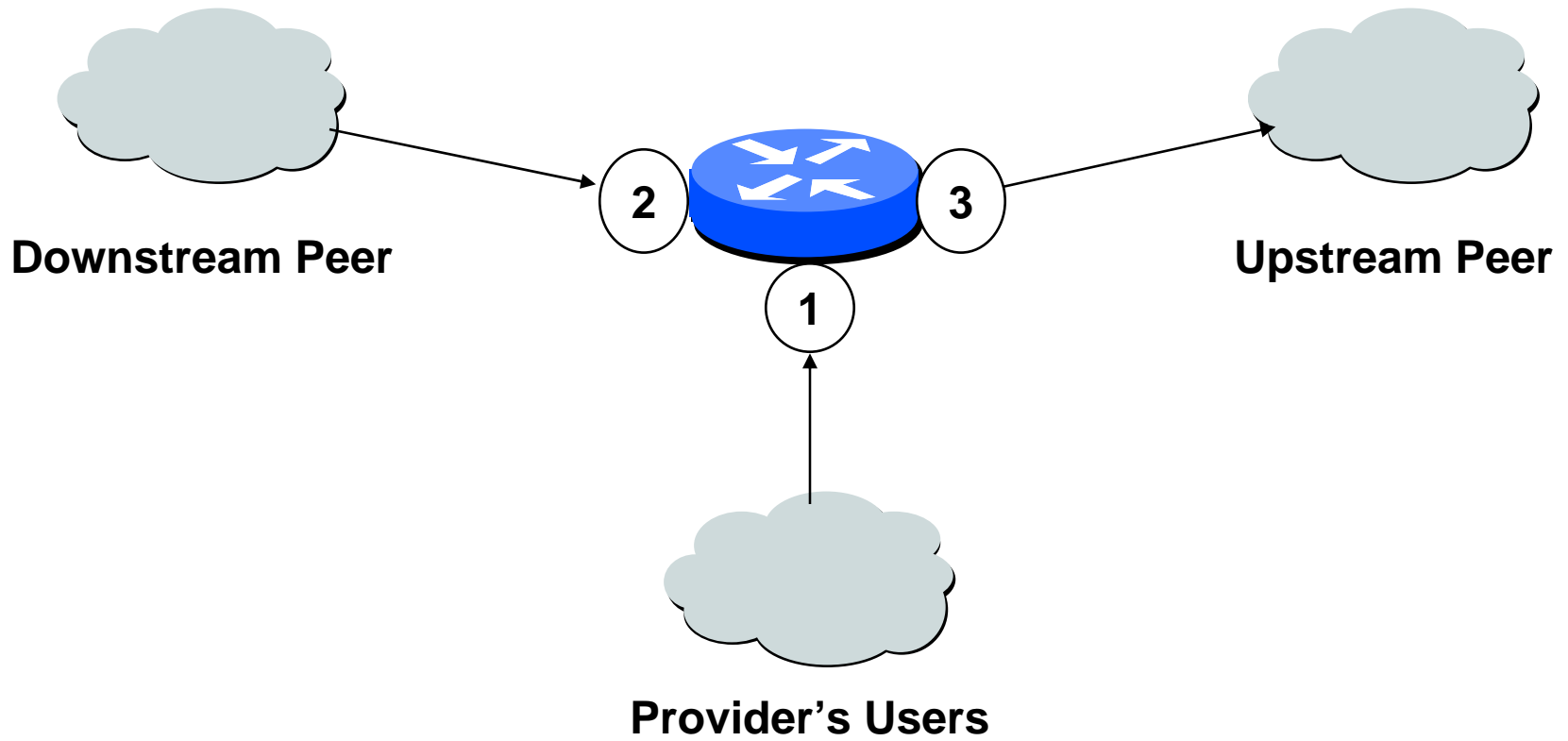
• End User RIP

Intended Usage

•End User RIP

Problems

•End User RIP
Enterprise and ISP Protective Measures

Provider Filtering\

Downstream Peer

Upstream Peer

2 **3**

1

Provider's Users

- **Enterprises Protect Themselves**

- **Sources to block**
  - Internal registered space
  - RFC1918
  - Known rogues

- **Destinations to block**
  - RFC 1918
  - Firewalled internal space
 - Unauthorized DMZ destinations

Externals & Aggregation 2

- ## In an enterprise
  - ### Limit externals from subordinate domains (e.g., RIP)
    - Flood only in area 0 and in area with ASBR
  - ### Allow externals from Internet, peer domains to go outside Area 0
    - Only when there will be significant path differences
    - Do things with defaults where possible

Type 1 and Type 2 externals

- **Type 2**
  - Default type for routes distributed into OSPF
  - Exit based on external cost only

- **Type 1**
  - Needs to be set explictly
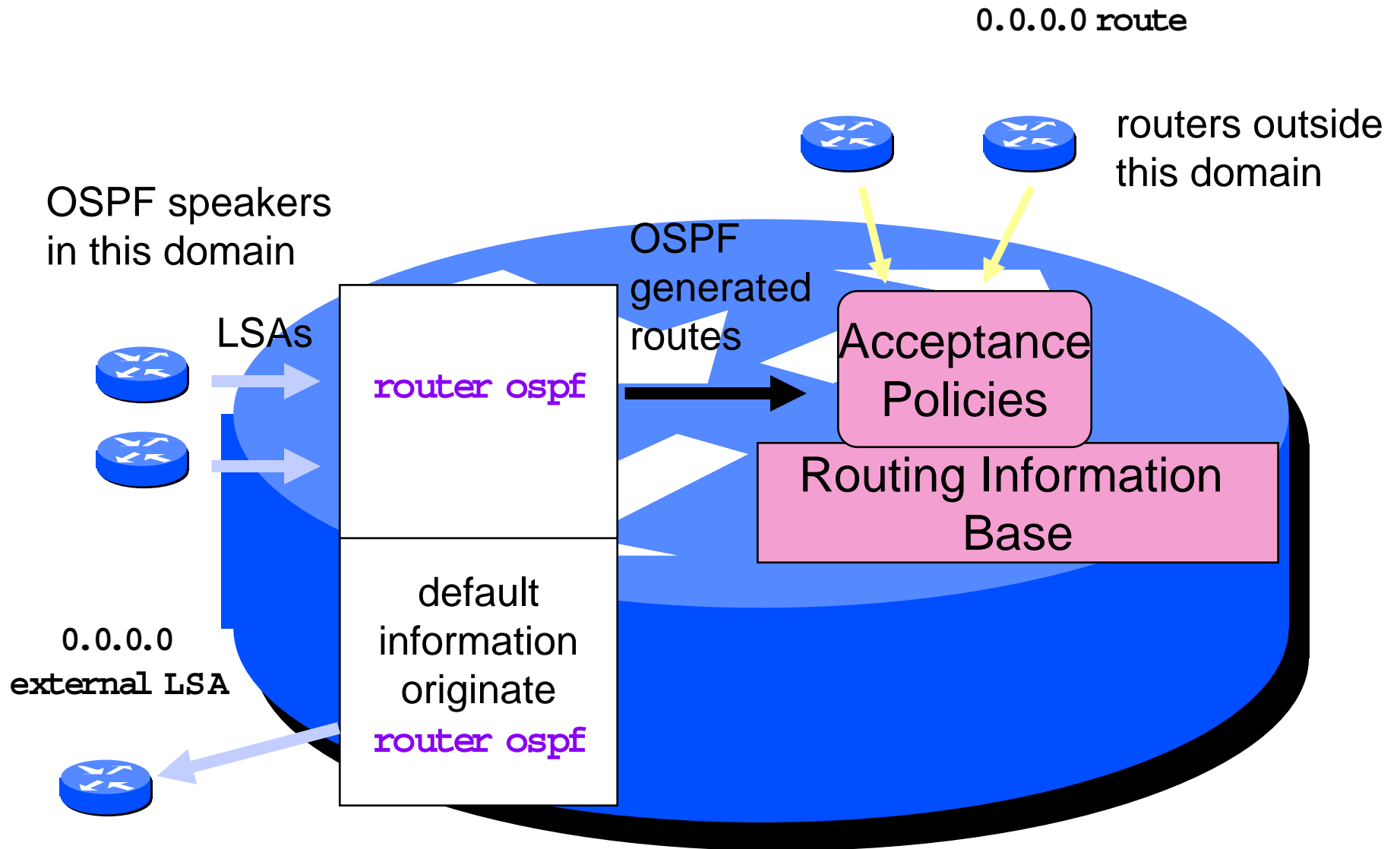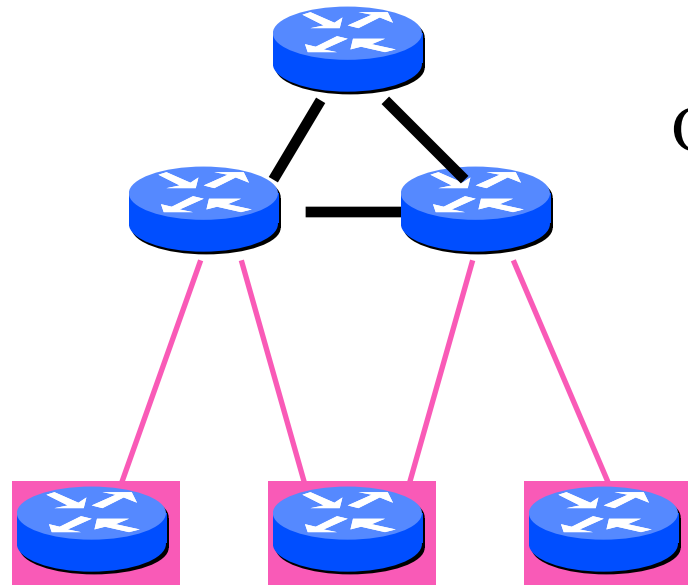 - Selects exit based on internal + external costs

ASBR Placement

Domain 1
Area 0

Domain 1
Area 1

Domain 1
Area 2
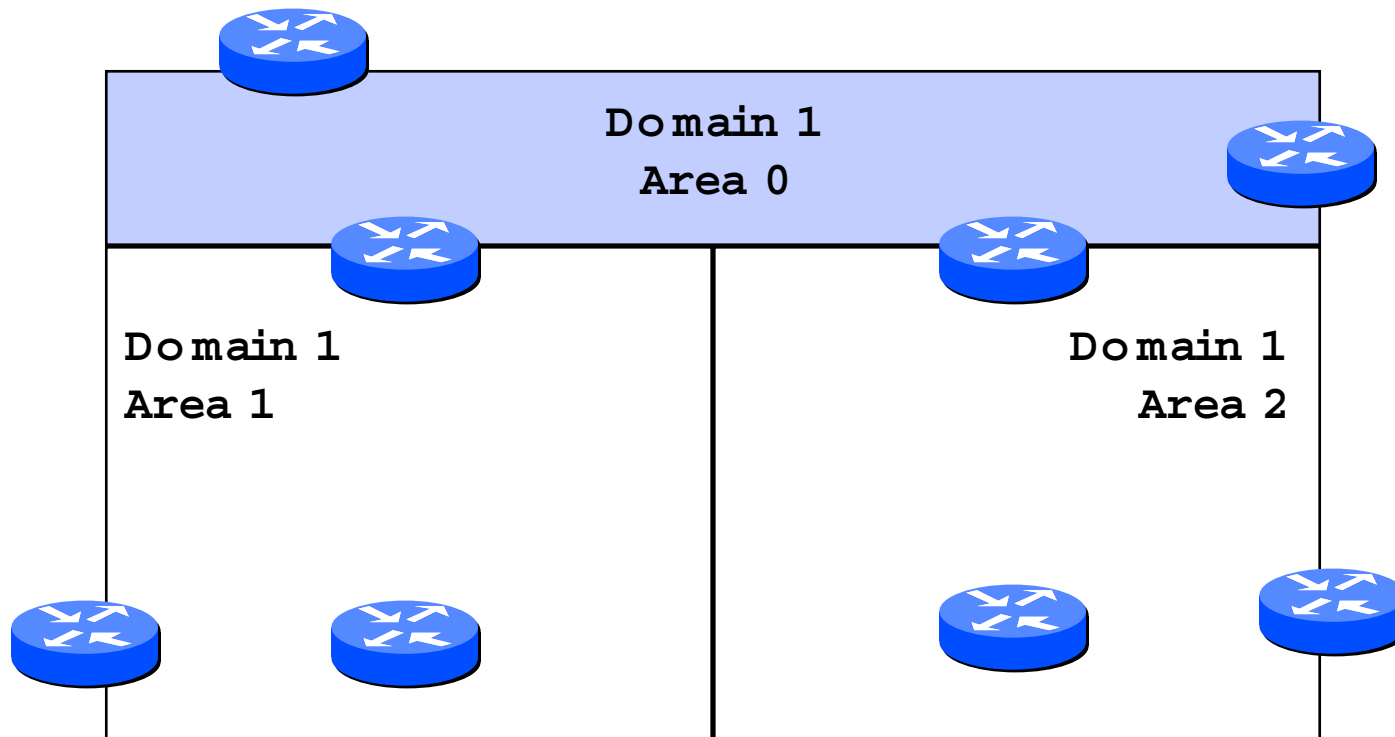
Contrary to common opinion…you can have ASBR
  outside area 0.
Nonzero area with ASBR can't be stubby or totally stubby

ASBR Default Information

0.0.0.0 `route`

routers outside this domain

OSPF speakers in this domain

OSPF generated routes

LSAs

`router ospf`

Acceptance Policies

Routing Information Base

0.0.0.0 external LSA

default information originate `router ospf`

OSPF and Default Routes

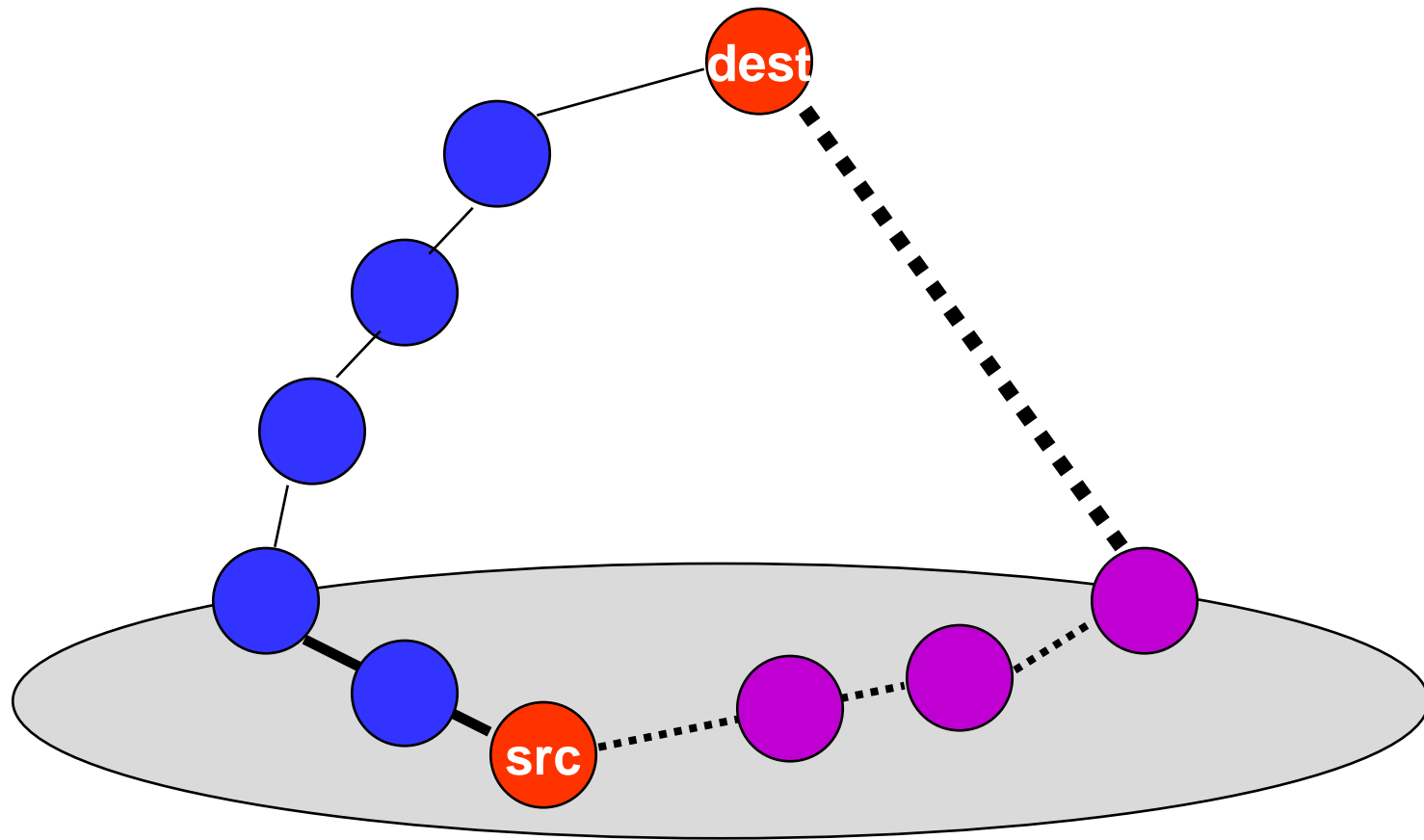OSPF Speakers

Edge routers
(note dual-homed default)

Stubbiness: A Means of Controlling Externals

Closest Exit Routing

- **Paths are not optimized end-to-end**
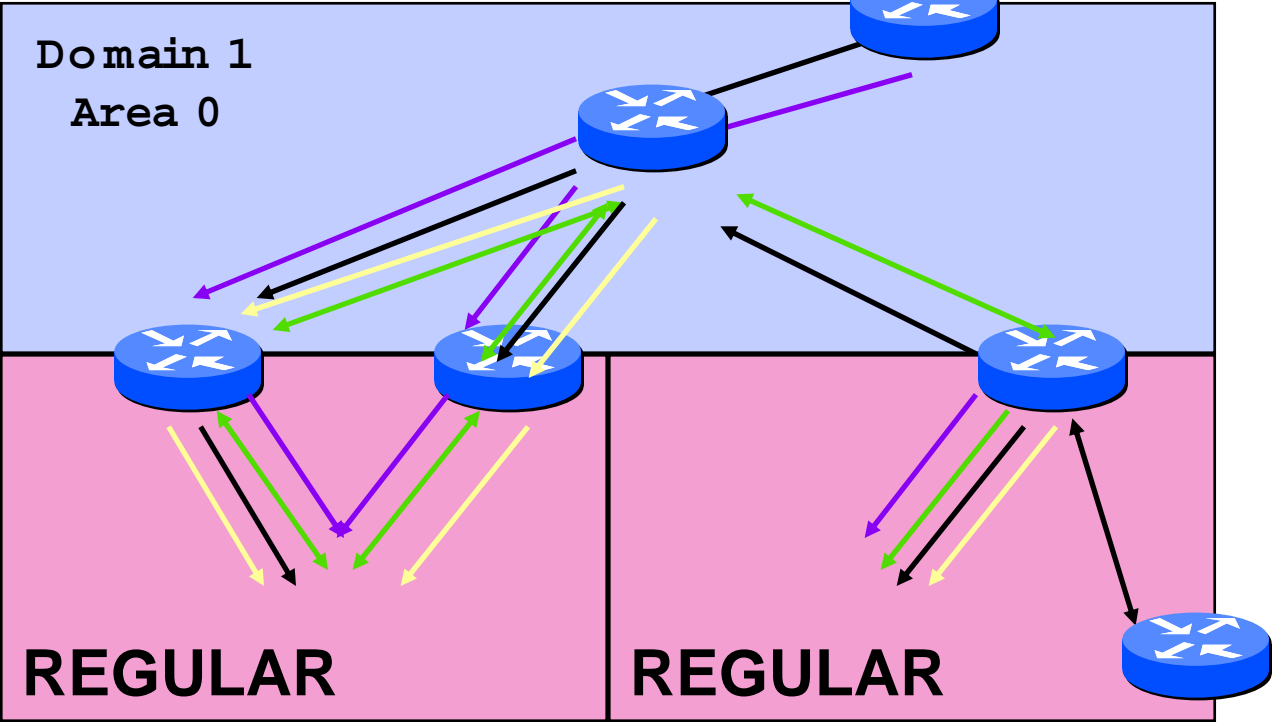- **Paths are optimized for each AS**

Asymmetrical Routing

- **No guarantee that traffic leaving your AS at one point**

- **Will return at the same point**

- **Remember**
  - **Each AS in both directions makes decisions on its information**

Regular Area

Specific internal,
Summary external,
Default

Specific external

Domain 1
Area 0

REGULAR

REGULAR

The idea of stubbiness

- **Reduce overhead in nonzero areas by reducing the number of externals**
- **Stubbiness helps only if there are significant numbers of externals**
  - But remember any redistributed route is external
  - Inside an OSPF domain, stubbiness does not help
- **External aggregation can help stubbiness**
- **Inter-area summarization complements stubbiness & aggregation for internal routes**

Restrictions with Stub Areas

- **Stubby**
  - Cannot have ASBR outside Area 0
  - Potential problem during migration
  - Potential problem for multiple Internet attachment points

- **Totally stubbly**
  - Single ABR; single point of failure
  - Cisco proprietary
  - Maximum traffic reduction

- **Not So Stubby**
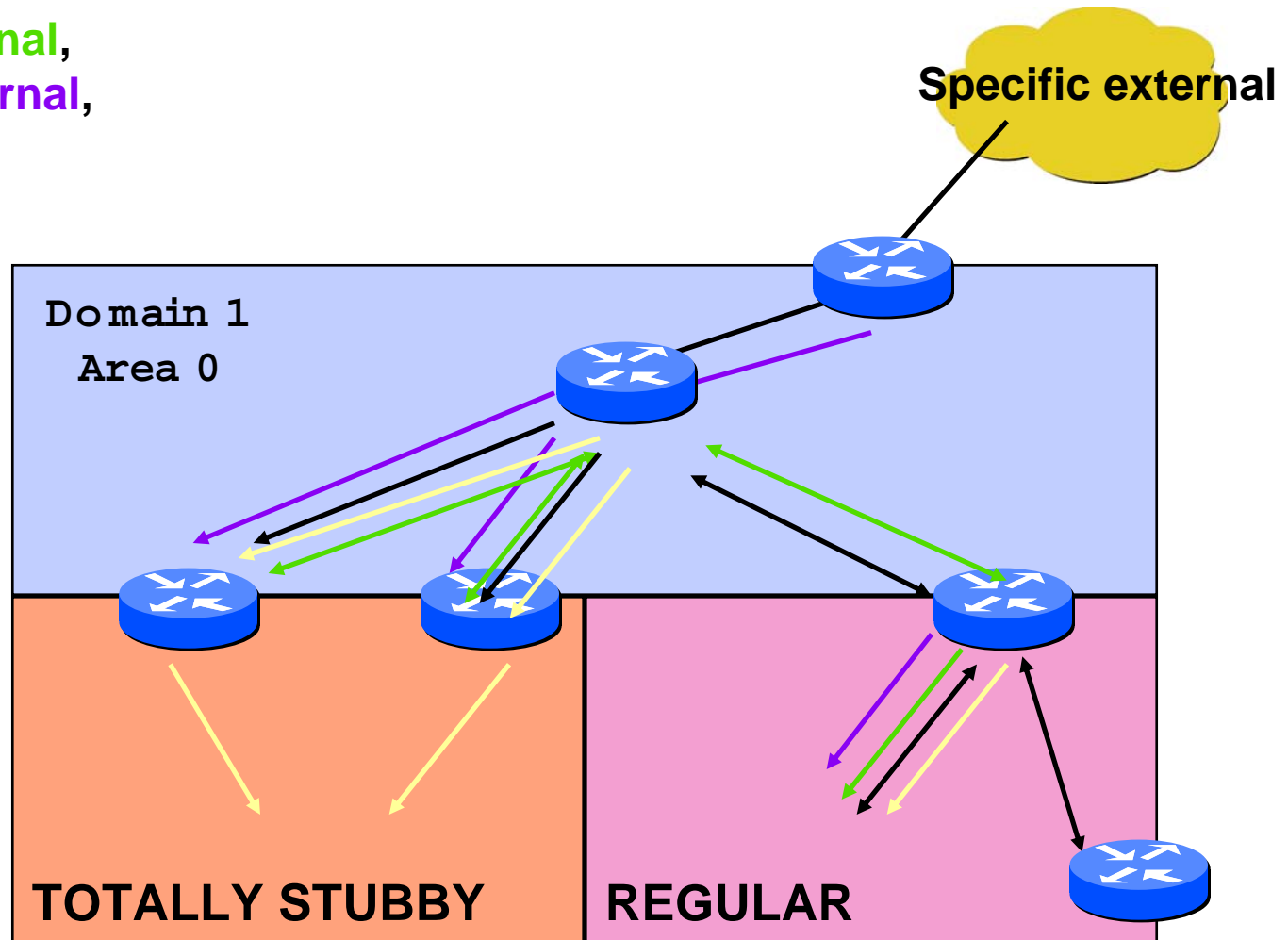 - Can only know externals injected into it by local ASBR

Stubby Area

Specific internal,
Summary external,
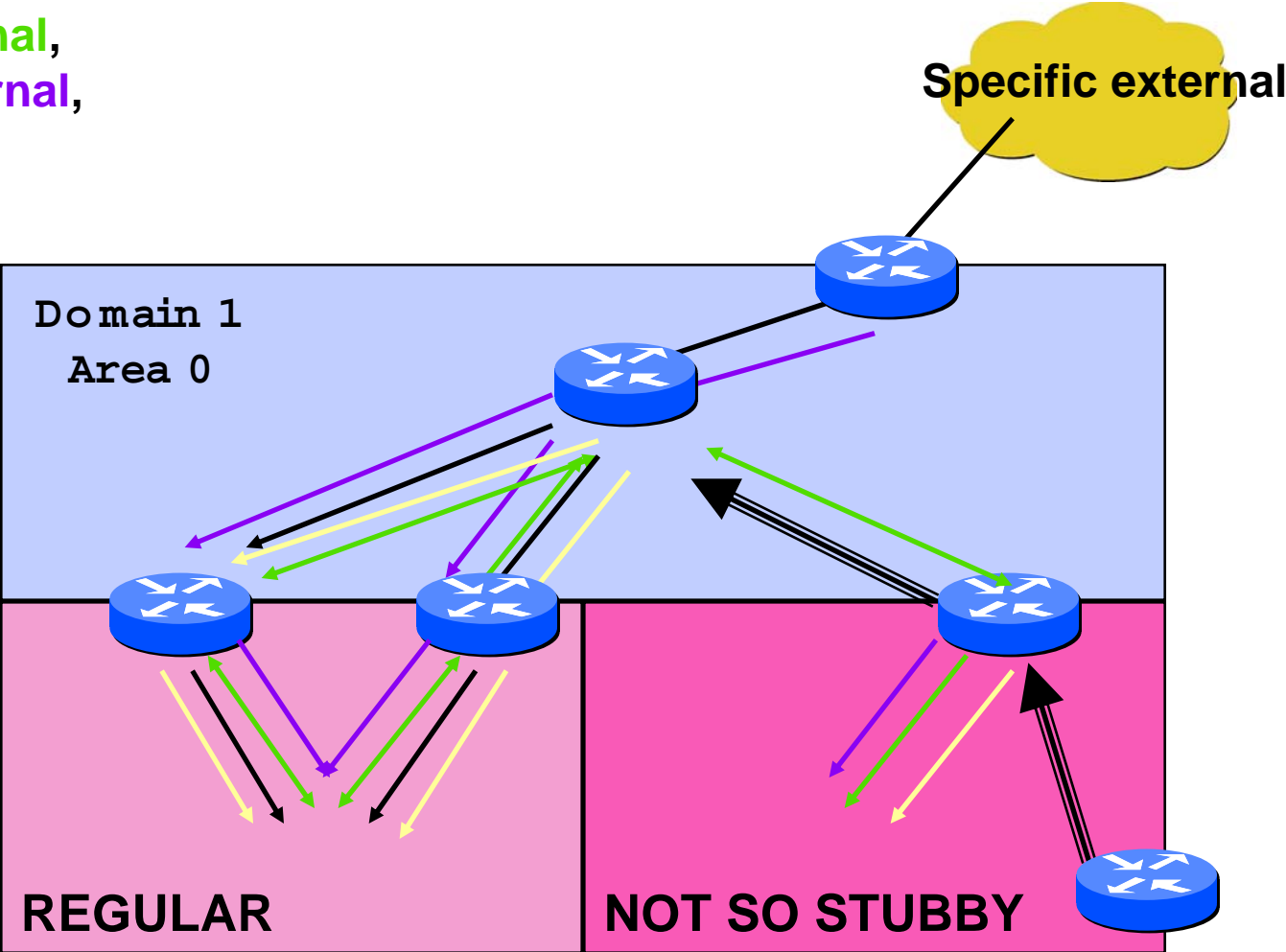**Default**

Specific external

Domain 1
Area 0

STUB

REGULAR
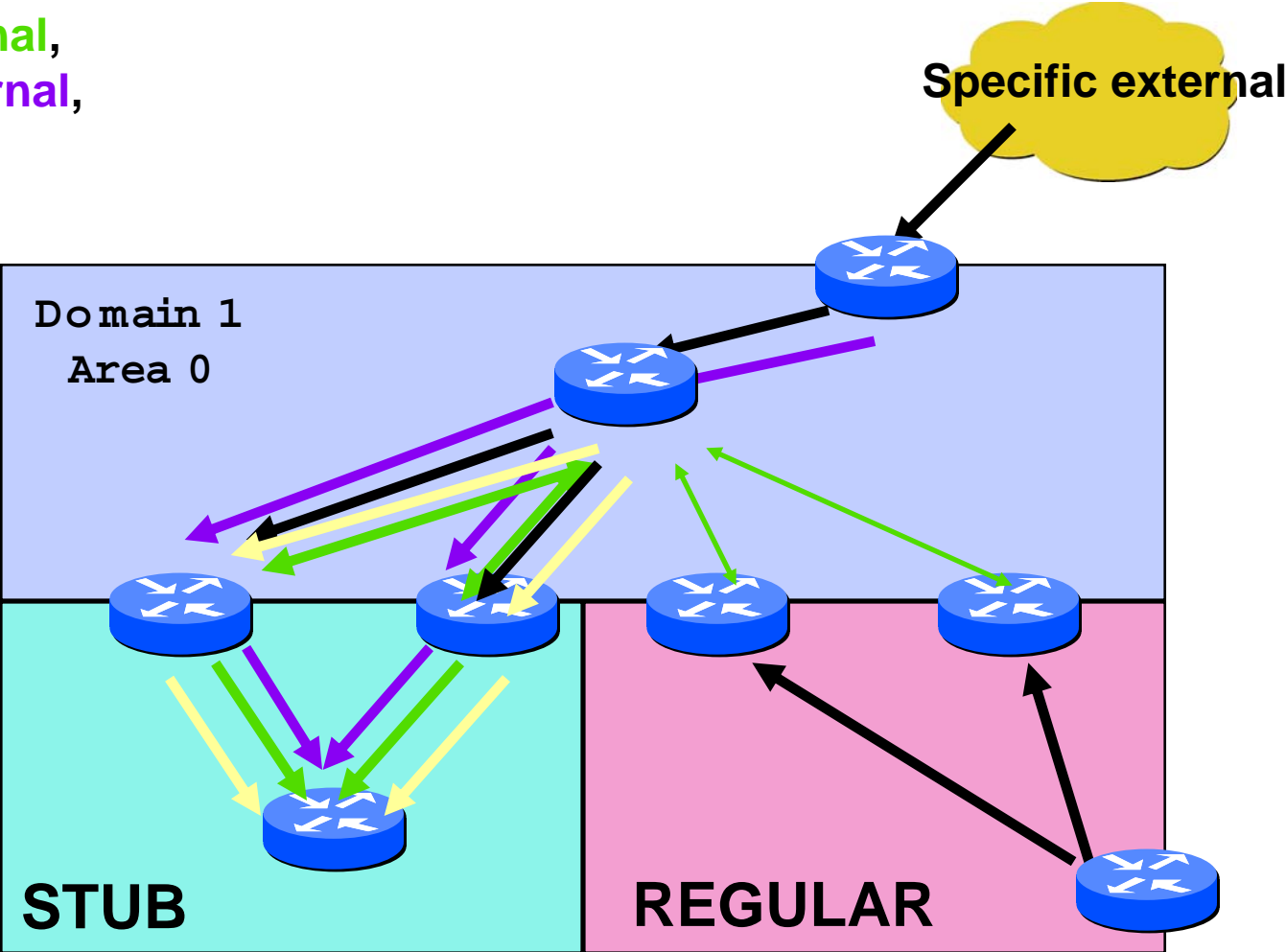
Totally Stubby Area

Specific internal,
Summary external,
Default

Specific external

Domain 1
Area 0

TOTALLY STUBBY   **REGULAR**

Not So Stubby Area

Specific internal,
Summary external,
Default

Specific external

Domain 1
Area 0

REGULAR

NOT SO STUBBY

Totally Stubby and also Not So Stubby

Specific internal,
Summary external,
Default

Specific external

Domain 1
Area 0

REGULAR

NOT SO STUBBY
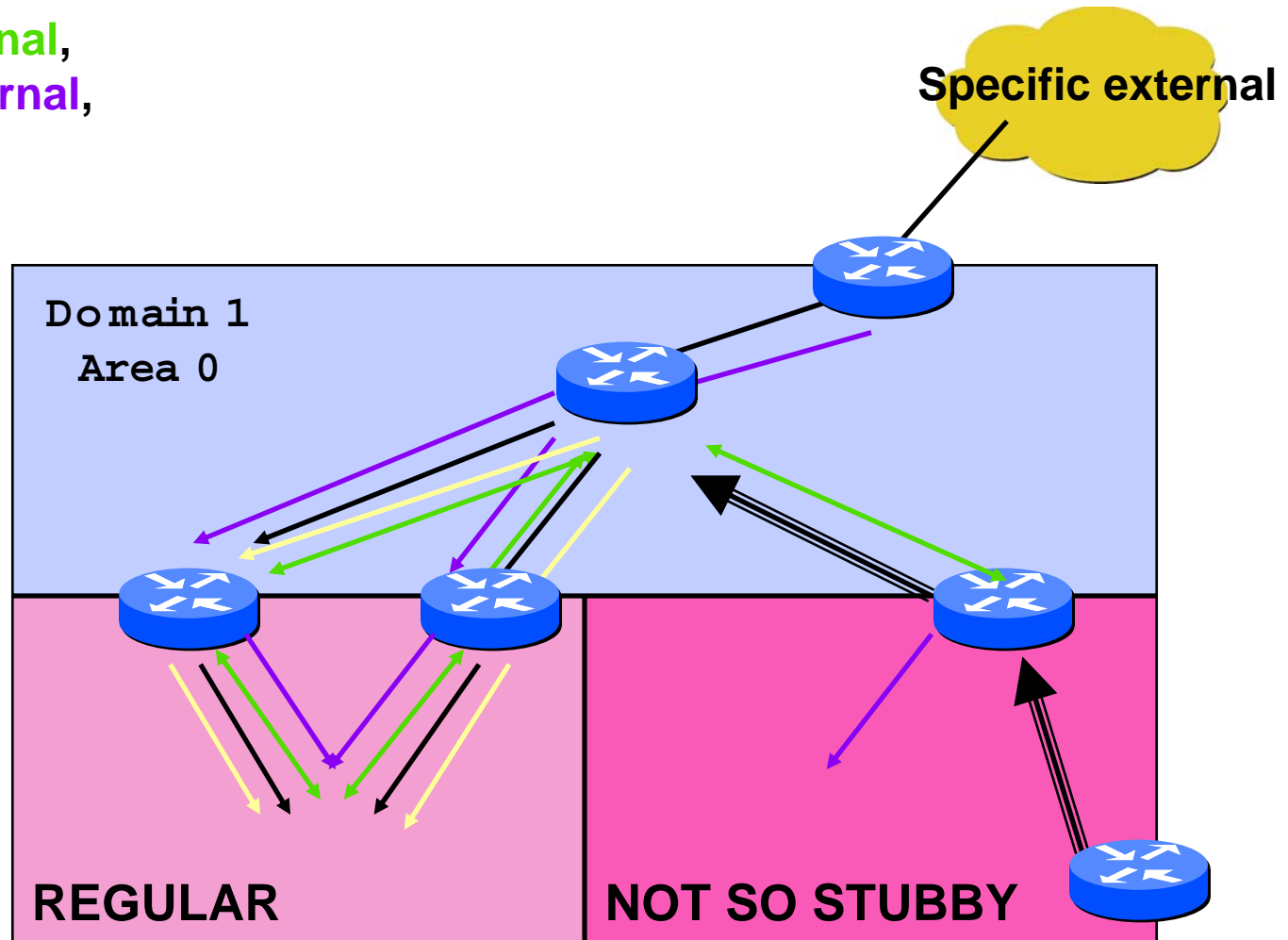
Redistribution

Redistribution = Acceptance

sources of **xxx** information

redistribute xxx under
router ospf

External LSAs

router ospf
(applies **default metric**)

Acceptance Policies

Routing Information Base

OSPF speakers
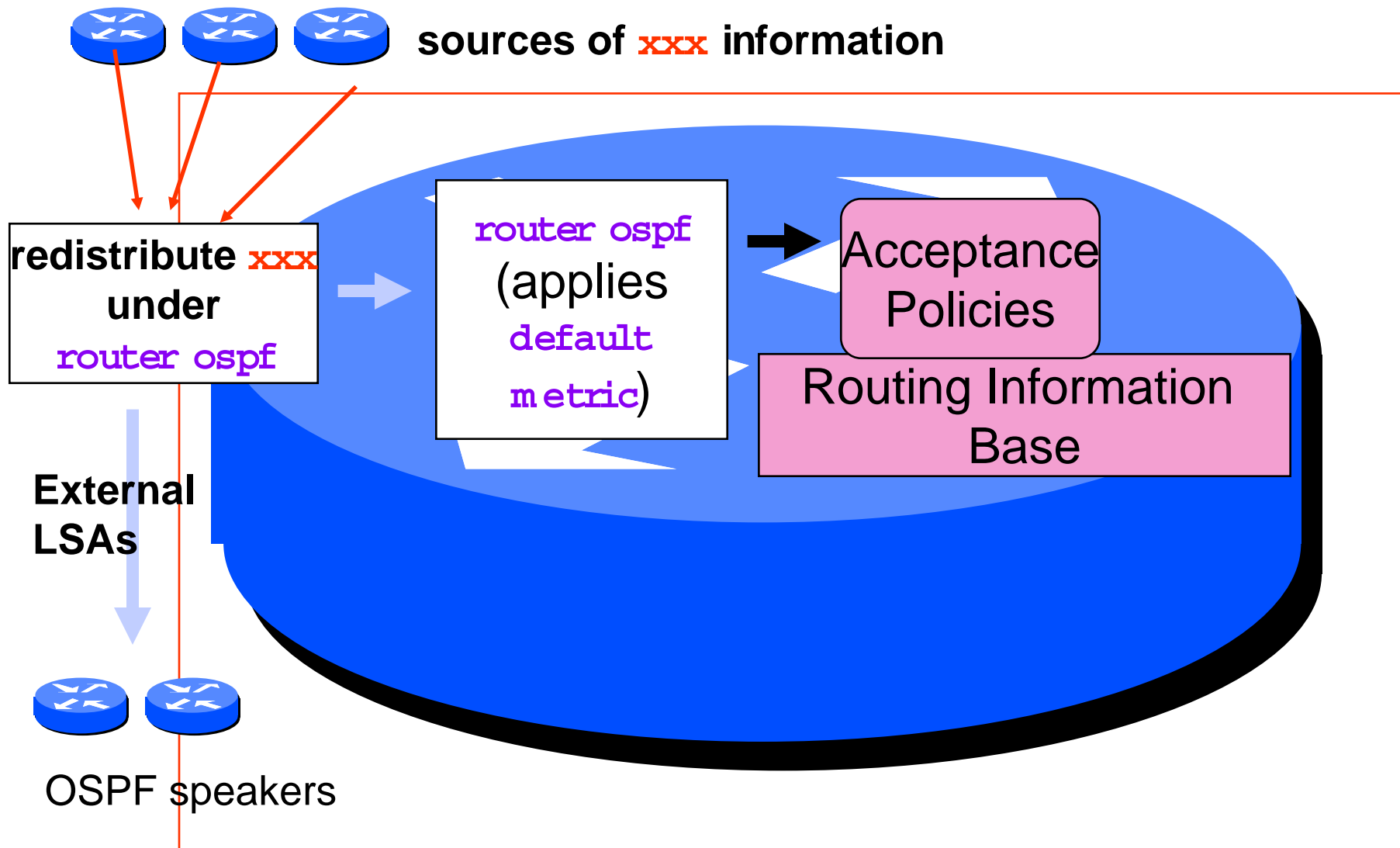
Hierarchical Redistribution

Core:
OSPF or EIGRP
dynamic routing

**Full routes
from
local domain
(except default)**

**Default
route
only**

Local use,
legacy, etc.
Protocols

X

Local use,
legacy, etc.
Protocols
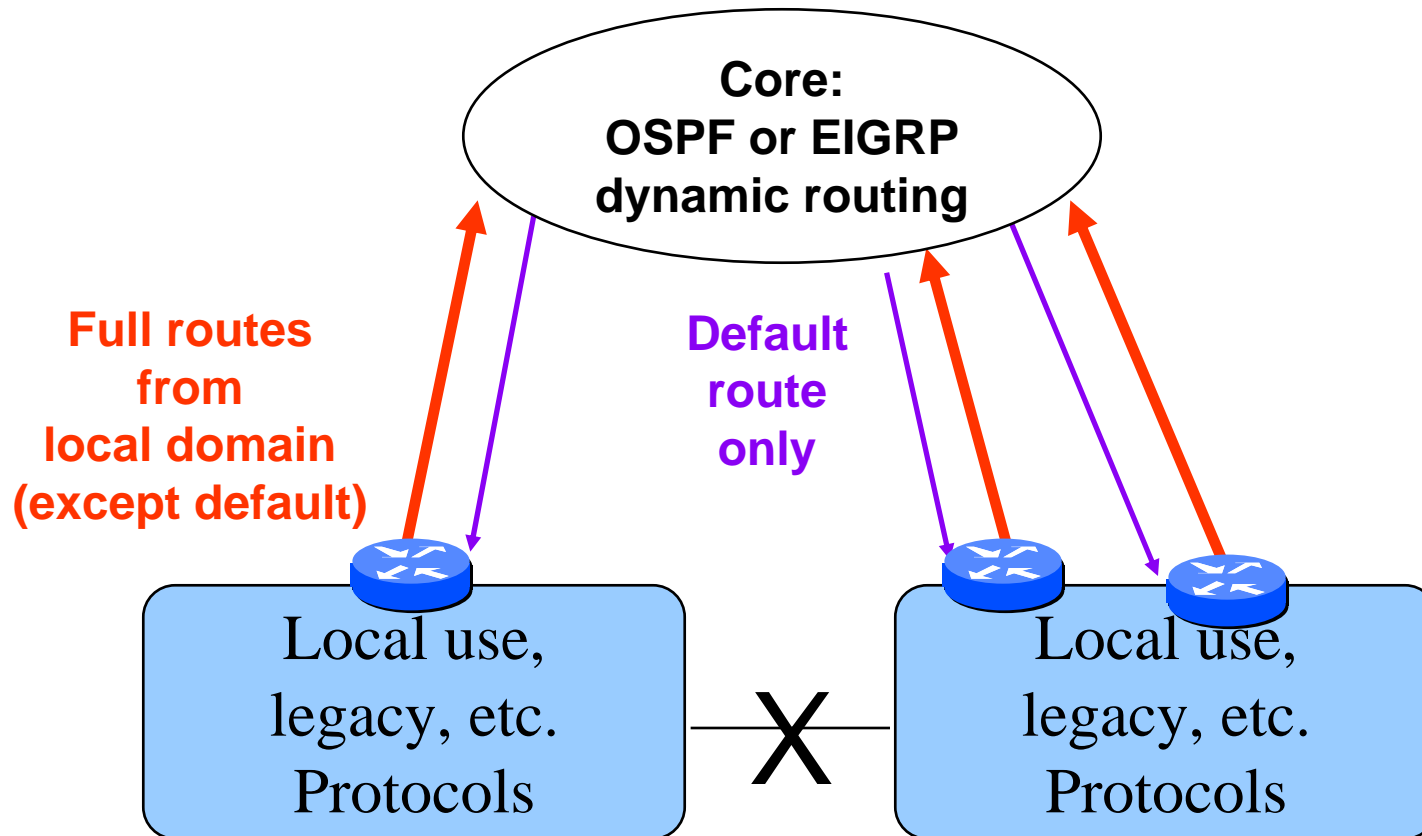
**Loop-free and easy to configure
Can use multiple routers**

Basic Mutual Redistribution

Default 1   Default 2

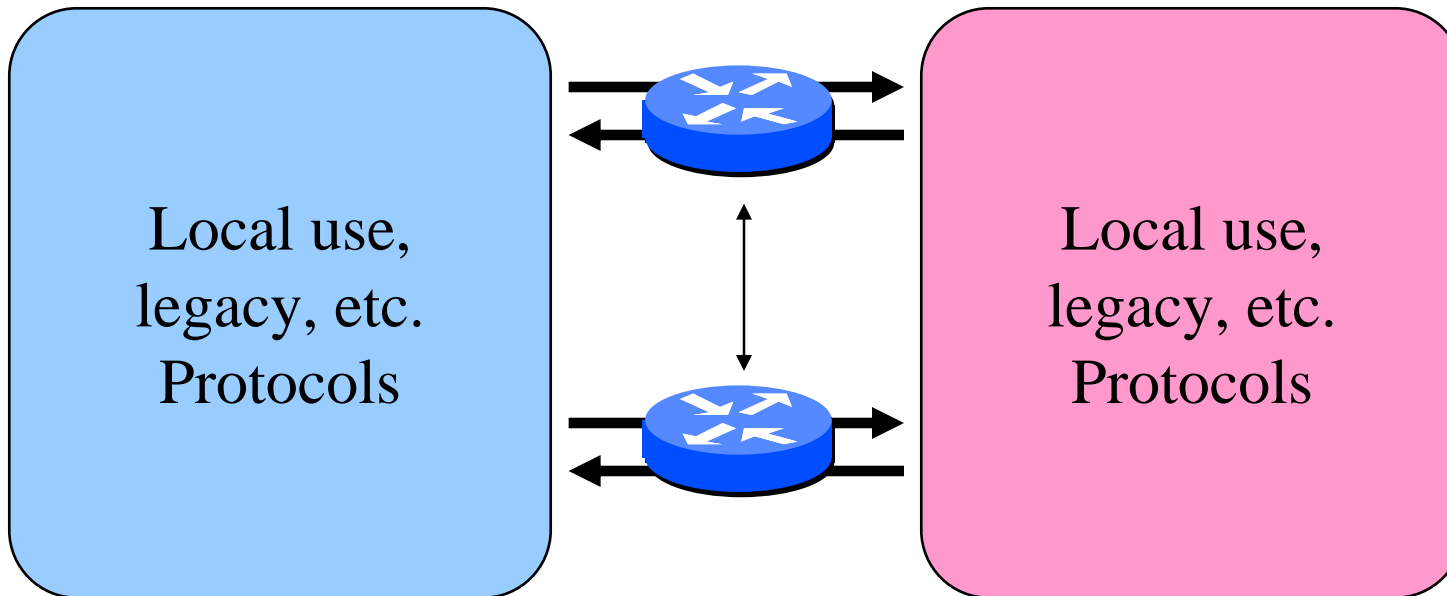| Local use,
legacy, etc.
Protocols | | Local use,
legacy, etc.
Protocols |
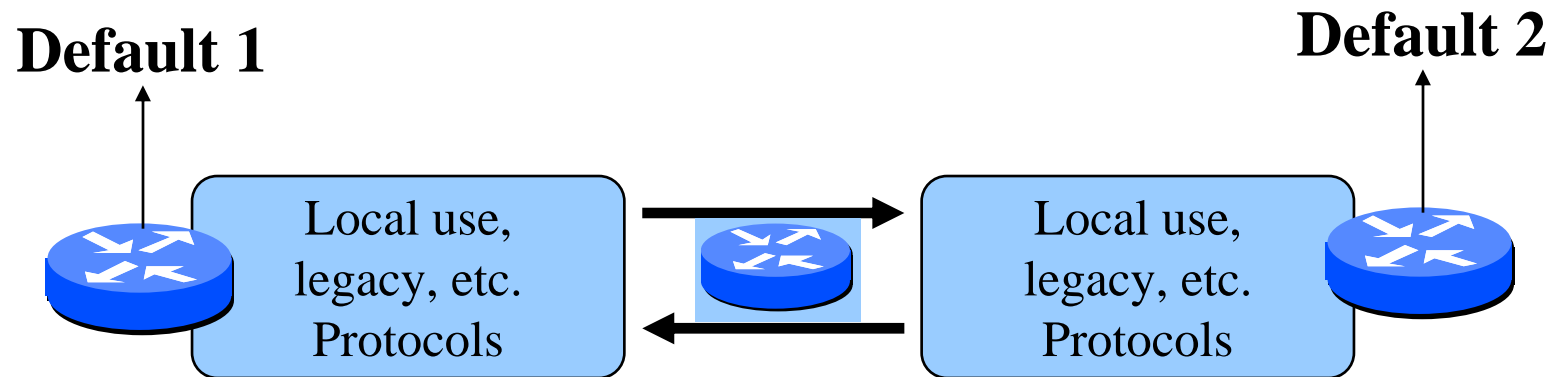
Manual configuration usually needed to prevent loops
Single redistributing router makes it much simpler
But is a single point of failure

Mutual Redistribution
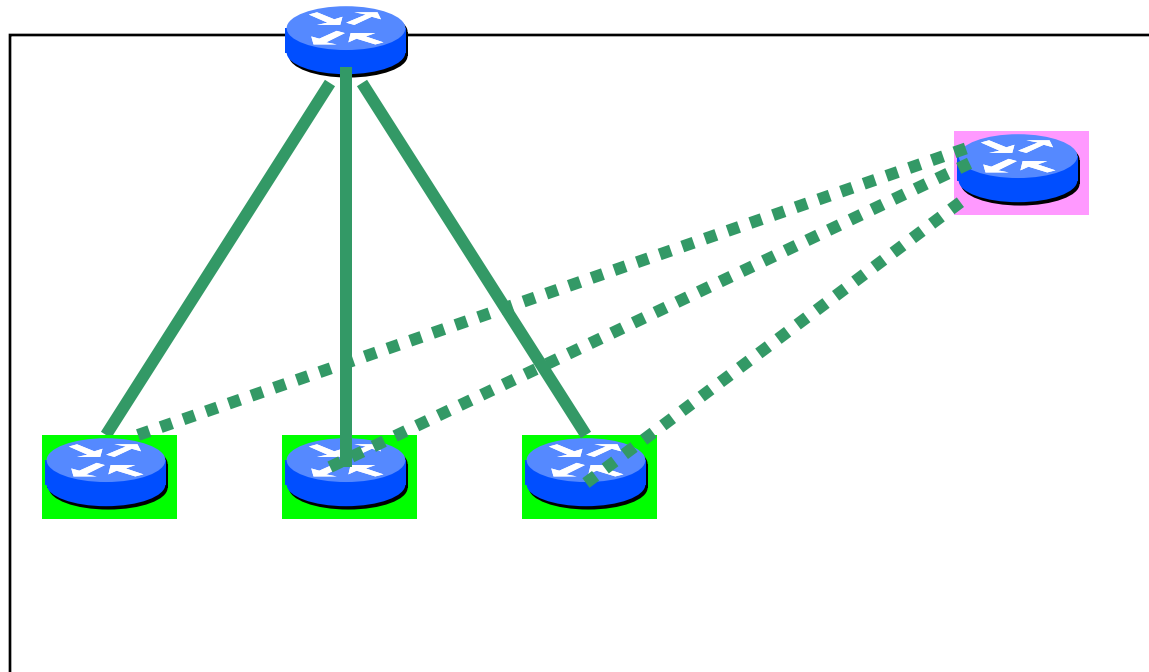## Multiple Redistribution Points

Local use,
legacy, etc.
Protocols

Local use,
legacy, etc.
Protocols

Extensive configuration usually needed to prevent loops
No single point of failure
Very hard to troubleshoot

OSPF and Default Routes
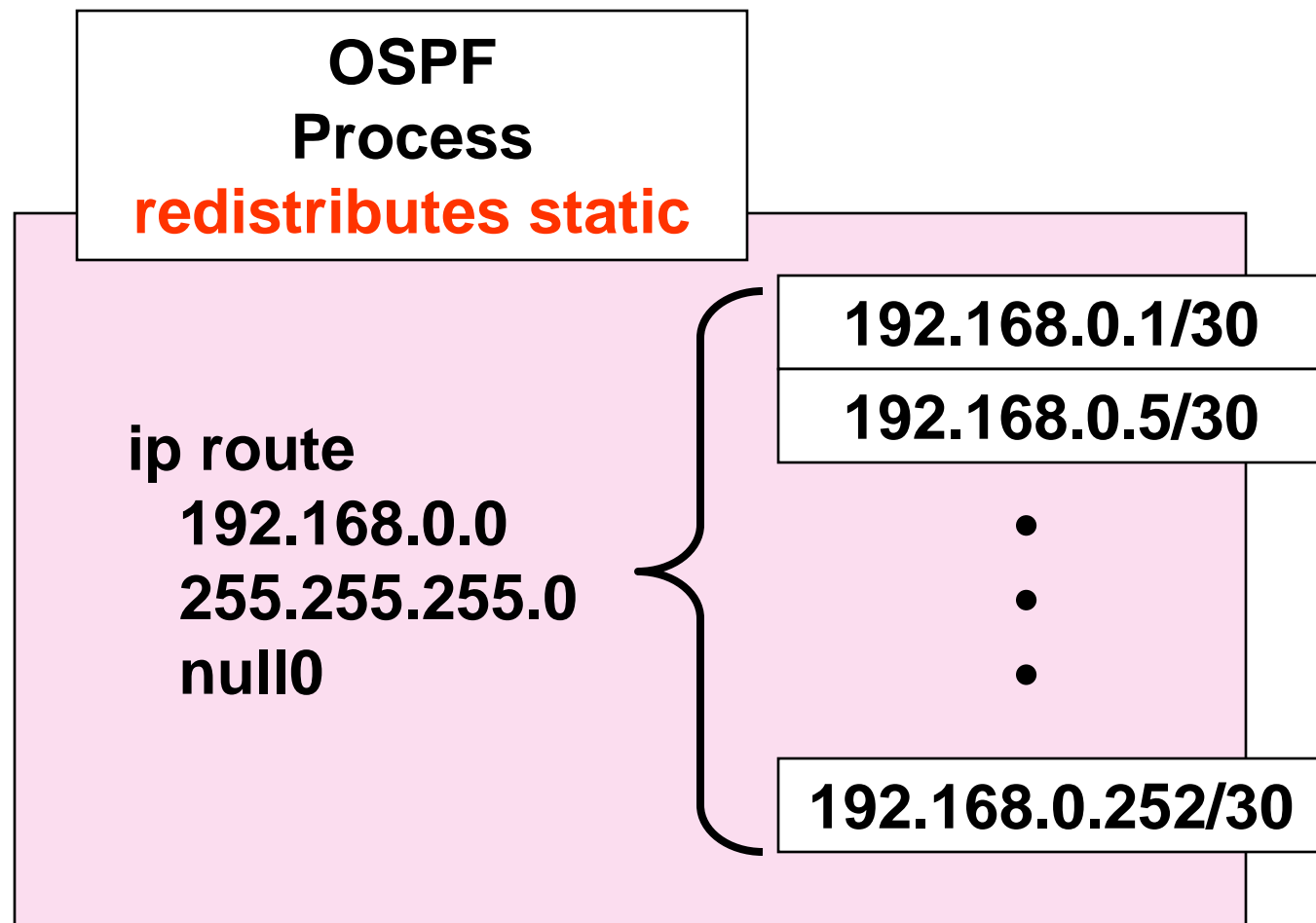
- ## OSPF convention
  - ### 0.0.0.0/0 (subnet mask 0.0.0.0)
  - ### Treated as external
  - ### May have different defaults in different areas
- ## Blackhole routes give pseudo-default

An Application of Blackhole Routes

Inside the Dial Server

OSPF Process
redistributes static

ip route
   192.168.0.0
   255.255.255.0
   null0

192.168.0.1/30

192.168.0.5/30

•
•
•

192.168.0.252/30

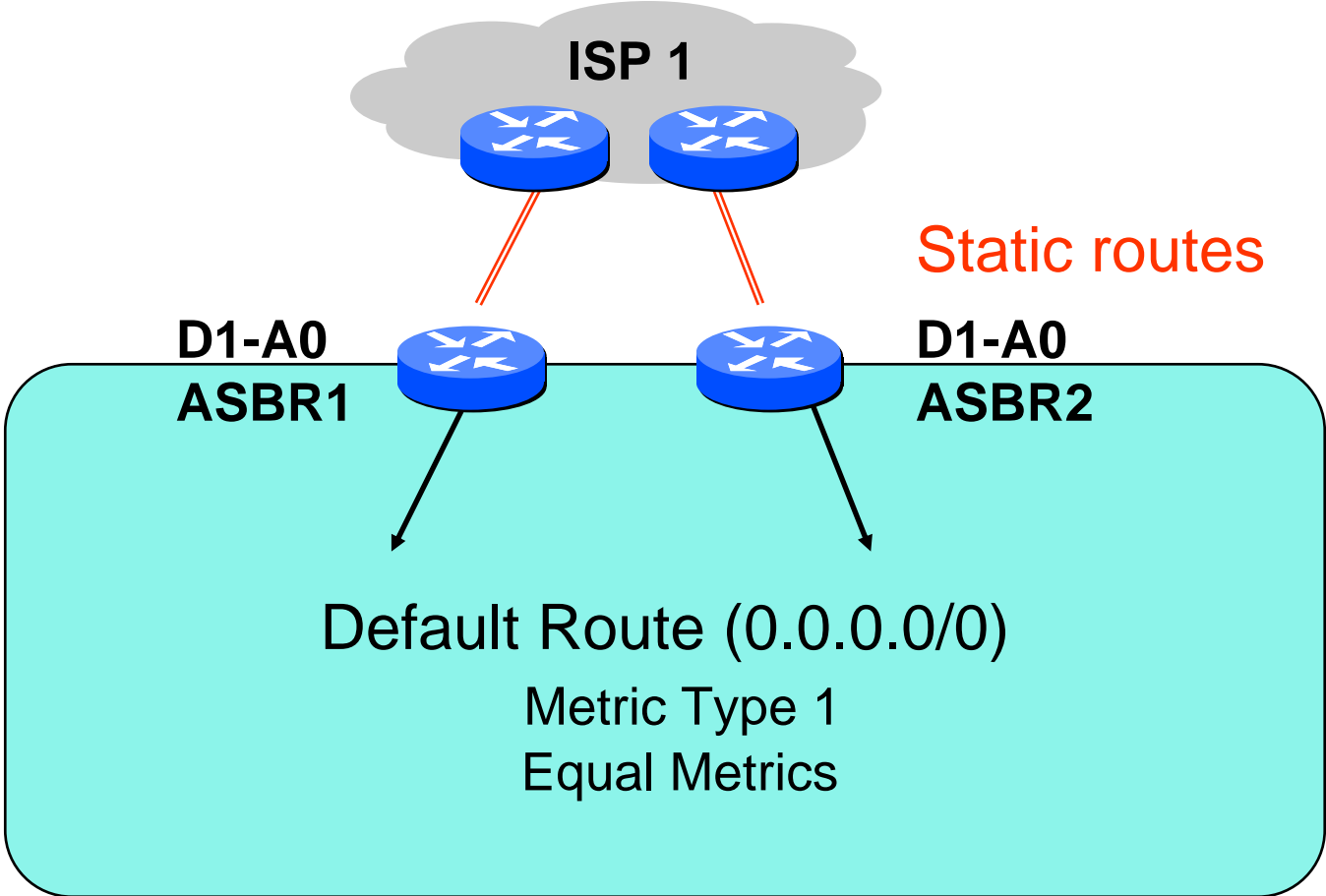# *Complex and Useful Domain Relationships*

A Trap to be Avoided:
Overemphasizing Area 0

- **A given domain has only only one Area 0**
- **But if there are scaling problems in a domain...**
- **Use multiple domains**
  - **Each with their own Area 0**
  - **Connecting to other OSPF and non-OSPF domains via ASBRs**
- **Use appropriate extensions**
  - **Virtual links**
  - **ASBRs outside Area 0**
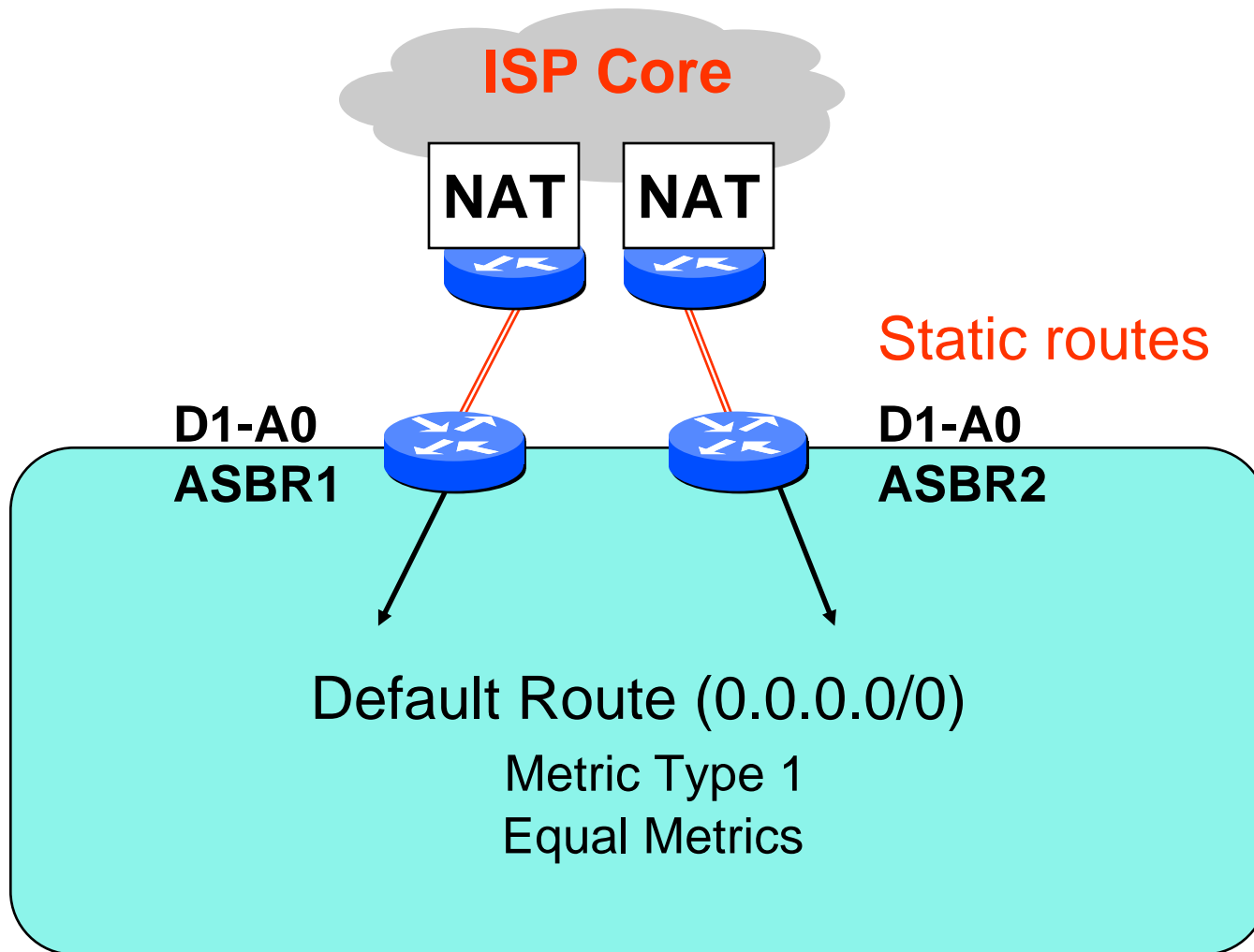   - **NSSAs a powerful new extension**

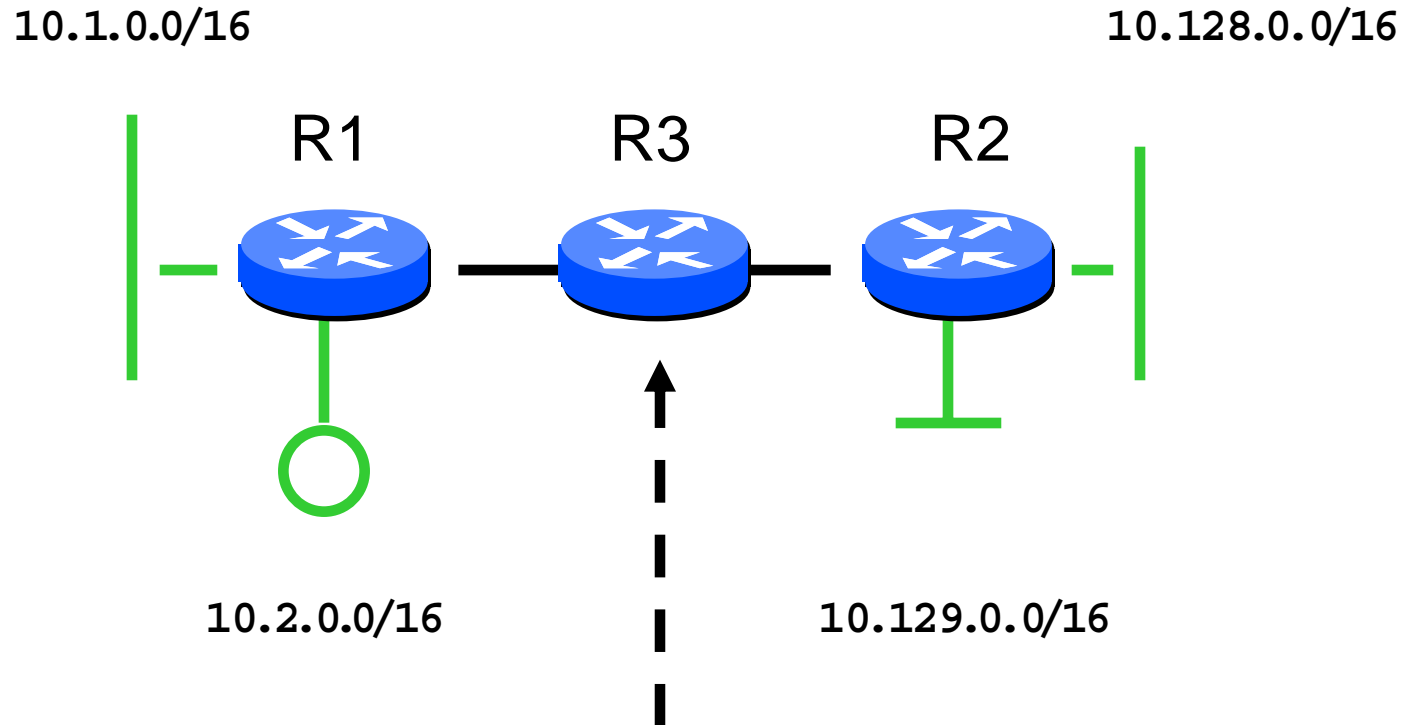# Access to Single ISP
Closest-Exit Load Sharing, No BGP Needed

ISP 1

Static routes

D1-A0
ASBR1

D1-A0
ASBR2

Default Route (0.0.0.0/0)

Metric Type 1
Equal Metrics

Multihoming with Customer RFC1918 Space

ISP Core

NAT   NAT

Static routes

D1-A0
ASBR1

D1-A0
ASBR2

Default Route (0.0.0.0/0)

Metric Type 1
Equal Metrics

Discontiguous Subnets
The Usual Enterprise-Oriented Picture

10.1.0.0/16   10.128.0.0/16

R1   R3   R2

10.2.0.0/16   10.129.0.0/16

If R3 only knows about "network 10,"
where does it send a packet for 10.64.0.0?

Discontiguous Subnets
Now it's the ISP's Problem

ISP

128.1.0.0/24

128.2.0.0/24

128.0.4.24

R1

R2

R3

128.0.0.0/24

128.0.3.0/24

128.0.5.0/24
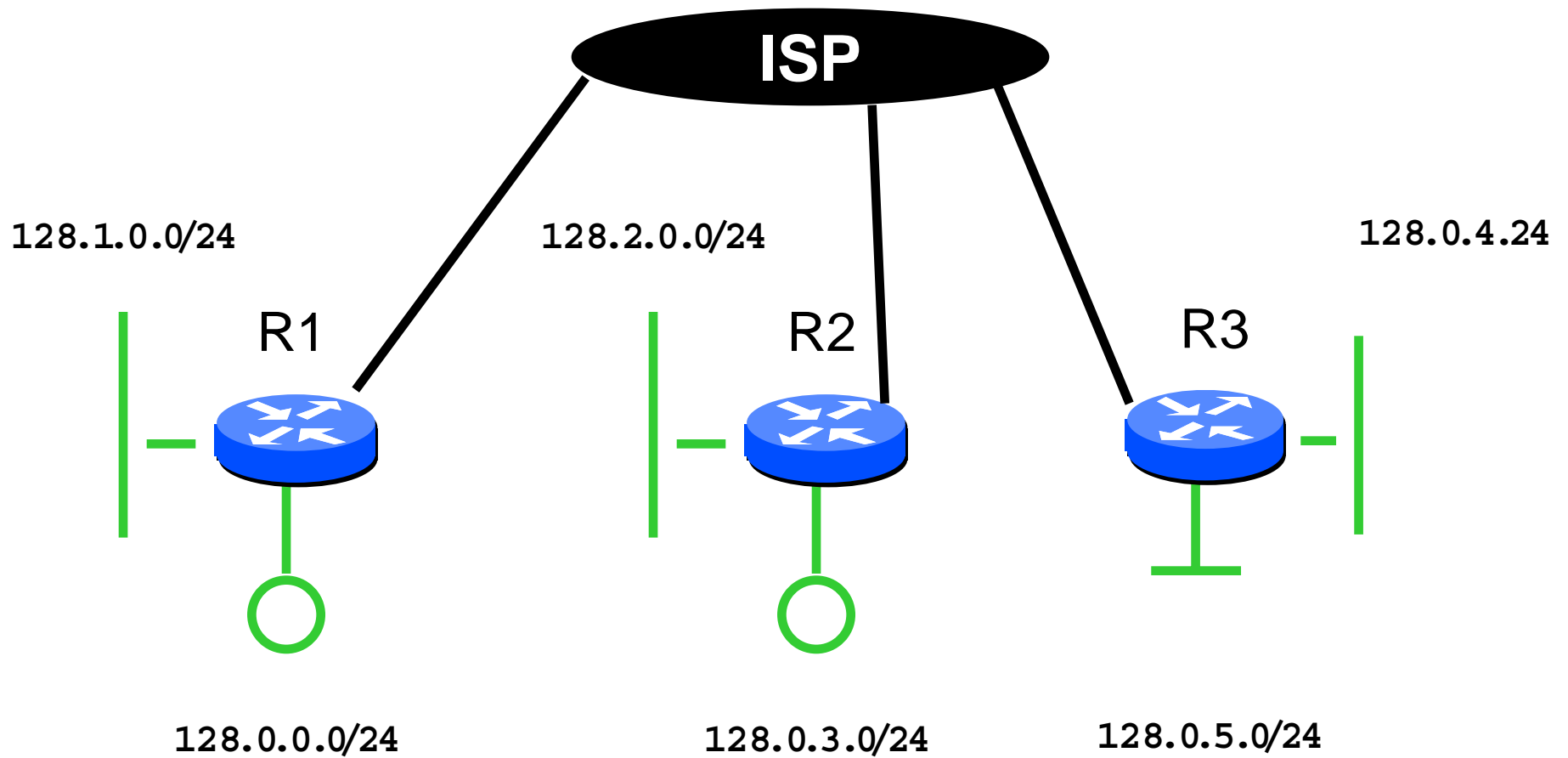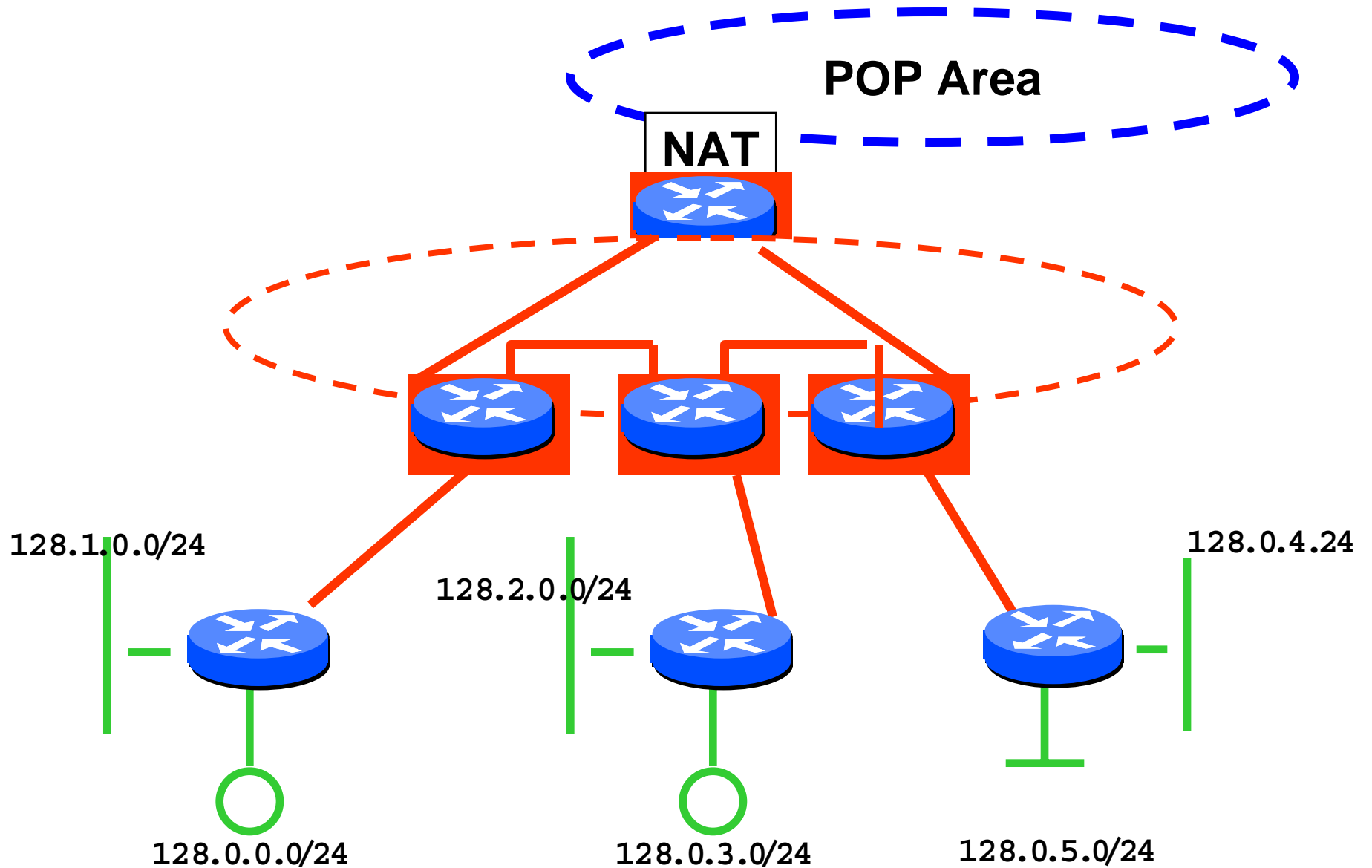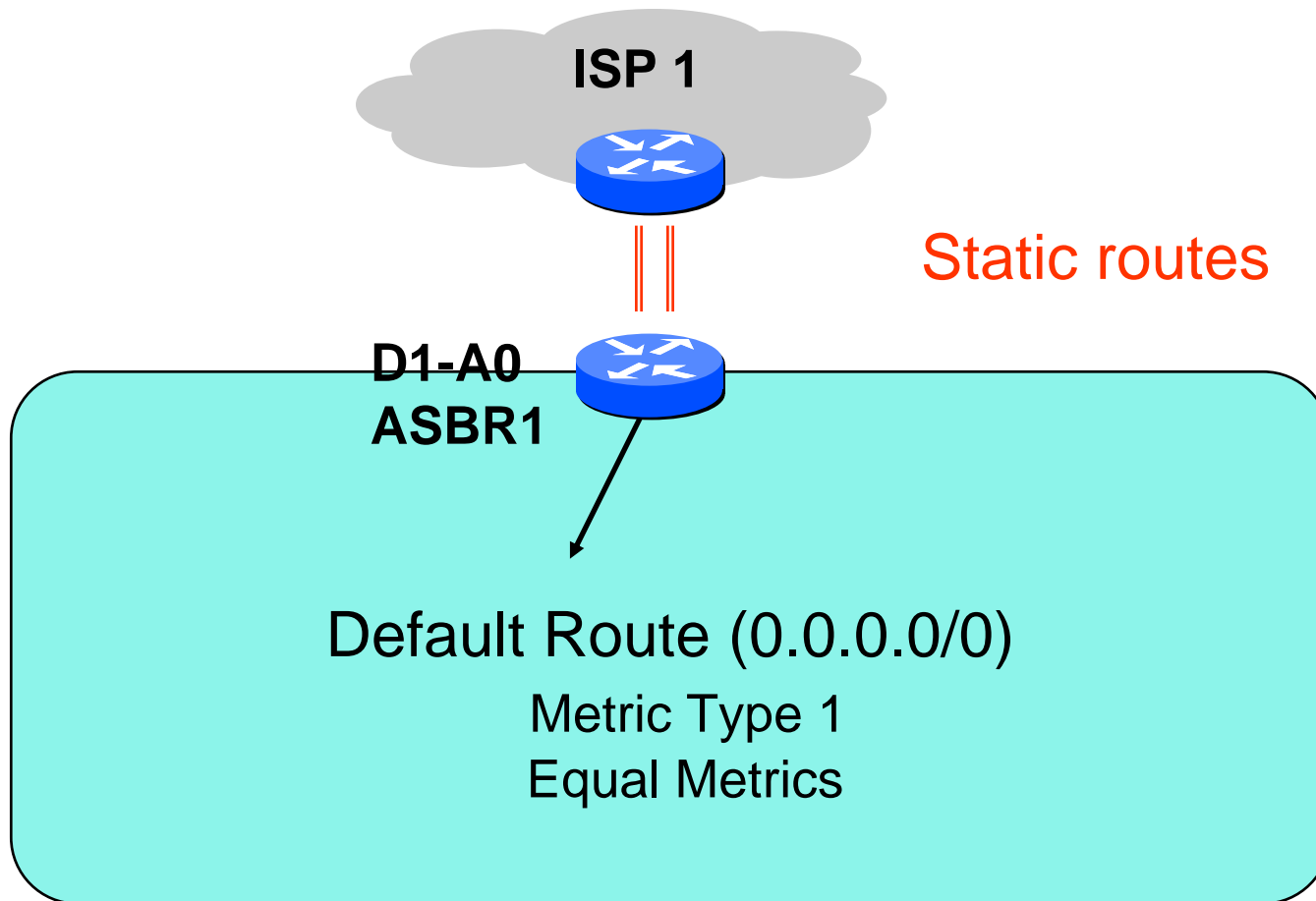
Healing Discontiguous Networks Techniques

- **Secondary addressing**
- **IP over IP tunneling**
- **IP unnumbered**
- **Static routes**
- **Network address translation**

- **Best way**
  - Move to classless environment
  - No more discontiguity
- **Care needed to deal with routing table growth**
  - Summarize where practical
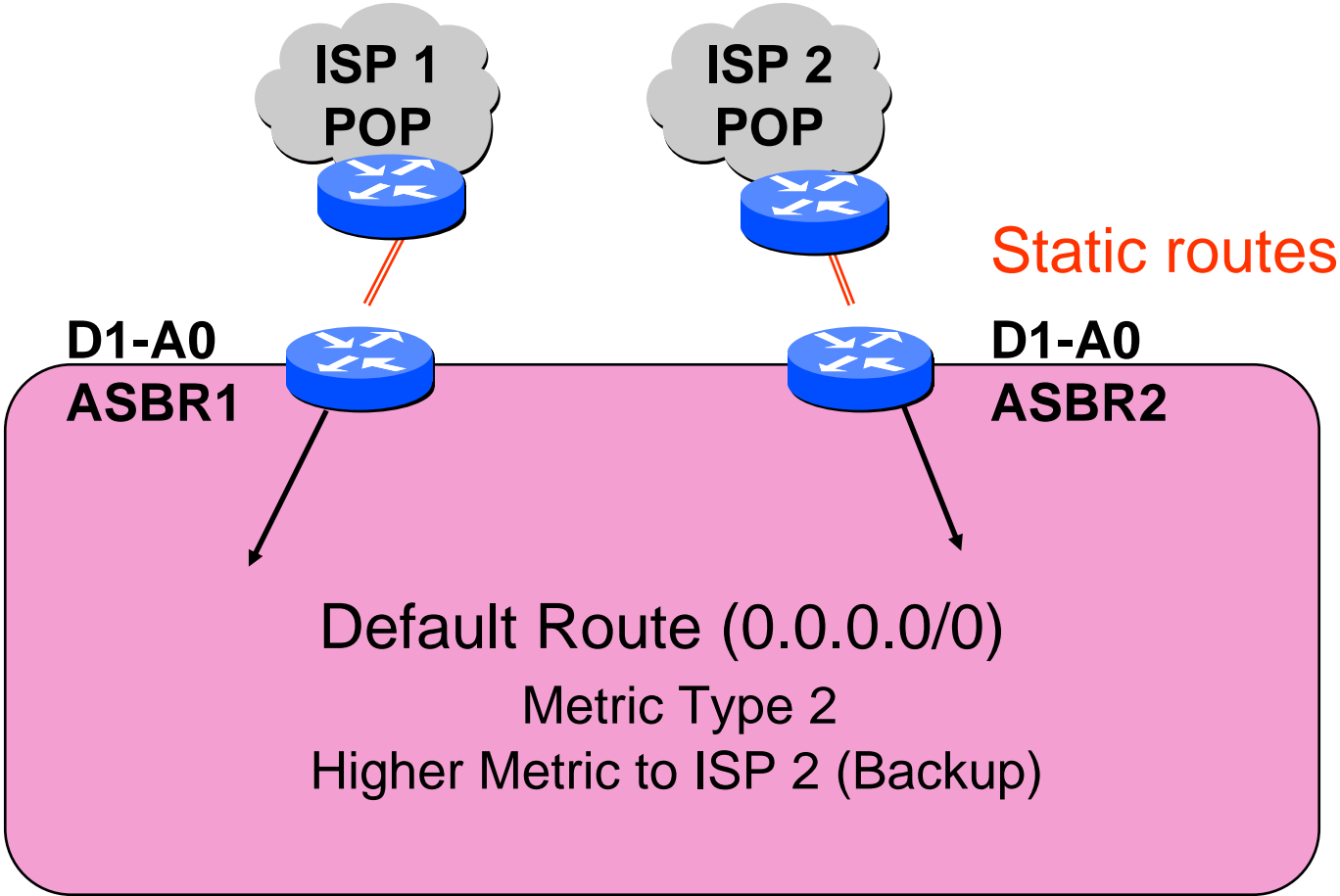 - Address assignment must be more careful

Dealing with Customers with Class

Single ISP
Link-Level Load Balancing

ISP 1

Static routes

D1-A0
ASBR1

Default Route (0.0.0.0/0)

Metric Type 1
Equal Metrics

Access to Primary & Backup ISP

ISP 1
POP

ISP 2
POP

Static routes

D1-A0

ASBR1

D1-A0

ASBR2

Default Route (0.0.0.0/0)

Metric Type 2
Higher Metric to ISP 2 (Backup)

Internet Access
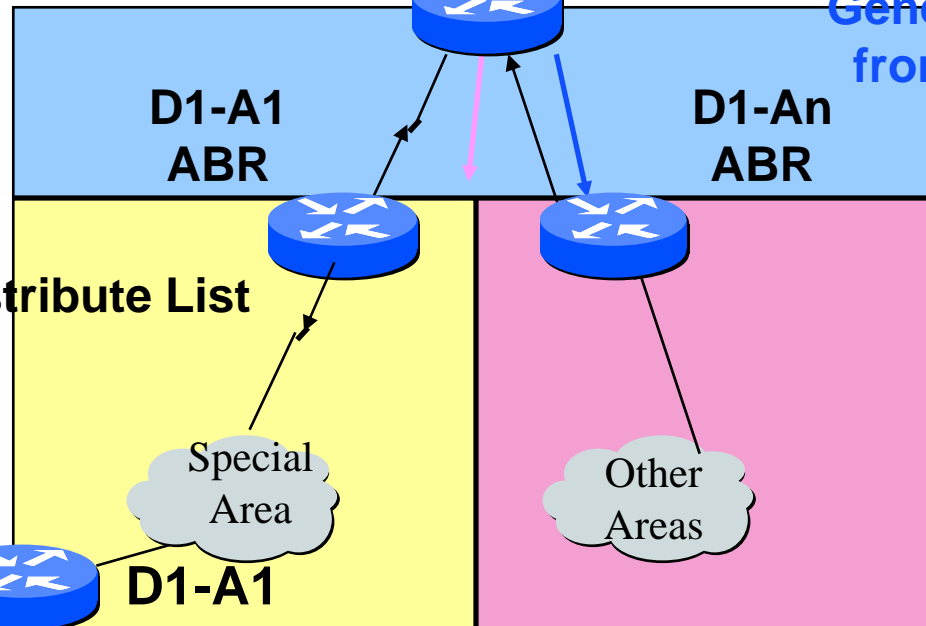## with Exception Case

Upstream Distribute List blocking 0.0.0.0 towards Area 0
Permits all other LSAs

ISP 1
POP

Static route

D1-A0 ASBR

General default route from Area 0

D1-A1 ABR

D1-An ABR

Downstream Distribute List blocking 0.0.0.0 towards Area 1

Special Area

Other Areas

ISP 2
POP

D1-A1 ASBR

RIP Migration

OSPF Area 0

OSPF Area 0 routing
aware of all OSPF &
RIP generated routes

D1-A1
ABR

D1-A2
ABR

D1-A1
ASBR

D1-A2
ASBR

OSPF routing processes
redistribute rip routes
except 0.0.0.0
injects all/part into Area 0
know about RIP routes
associated with their area

RIP 1

RIP 2

RIP routing processes
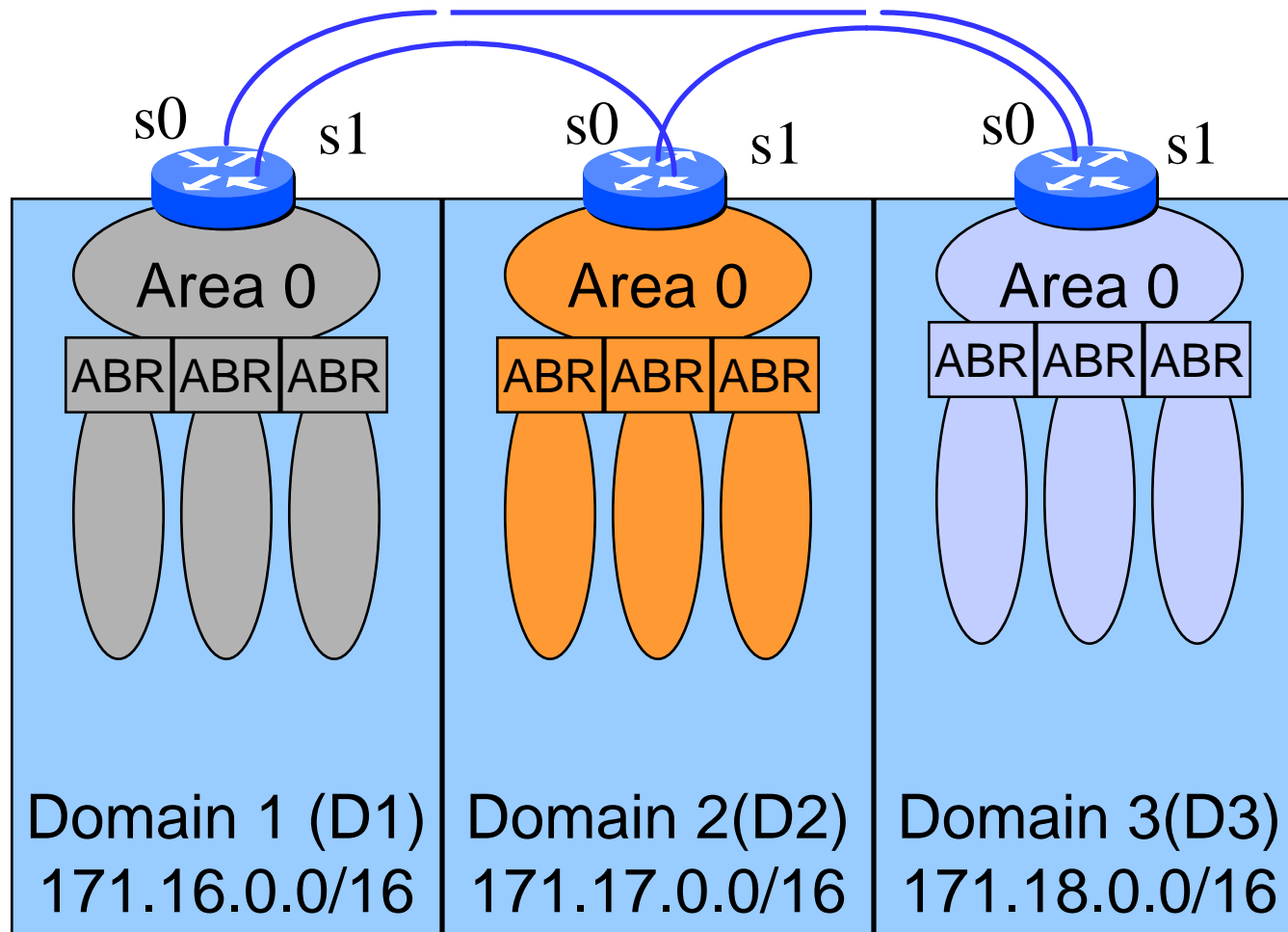redistribute 0.0.0.0
from OSPF into RIP
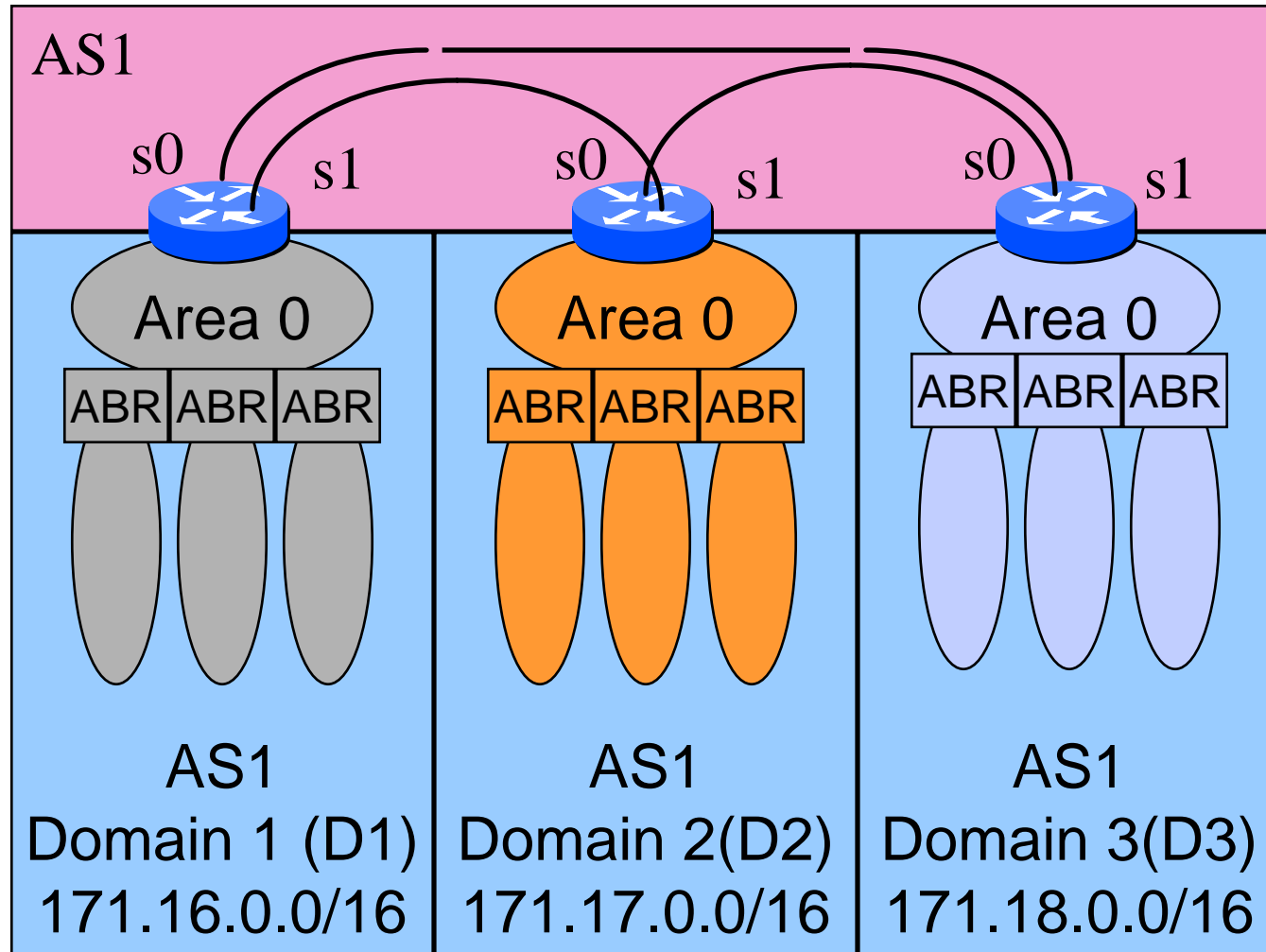unaware of other RIP
domains
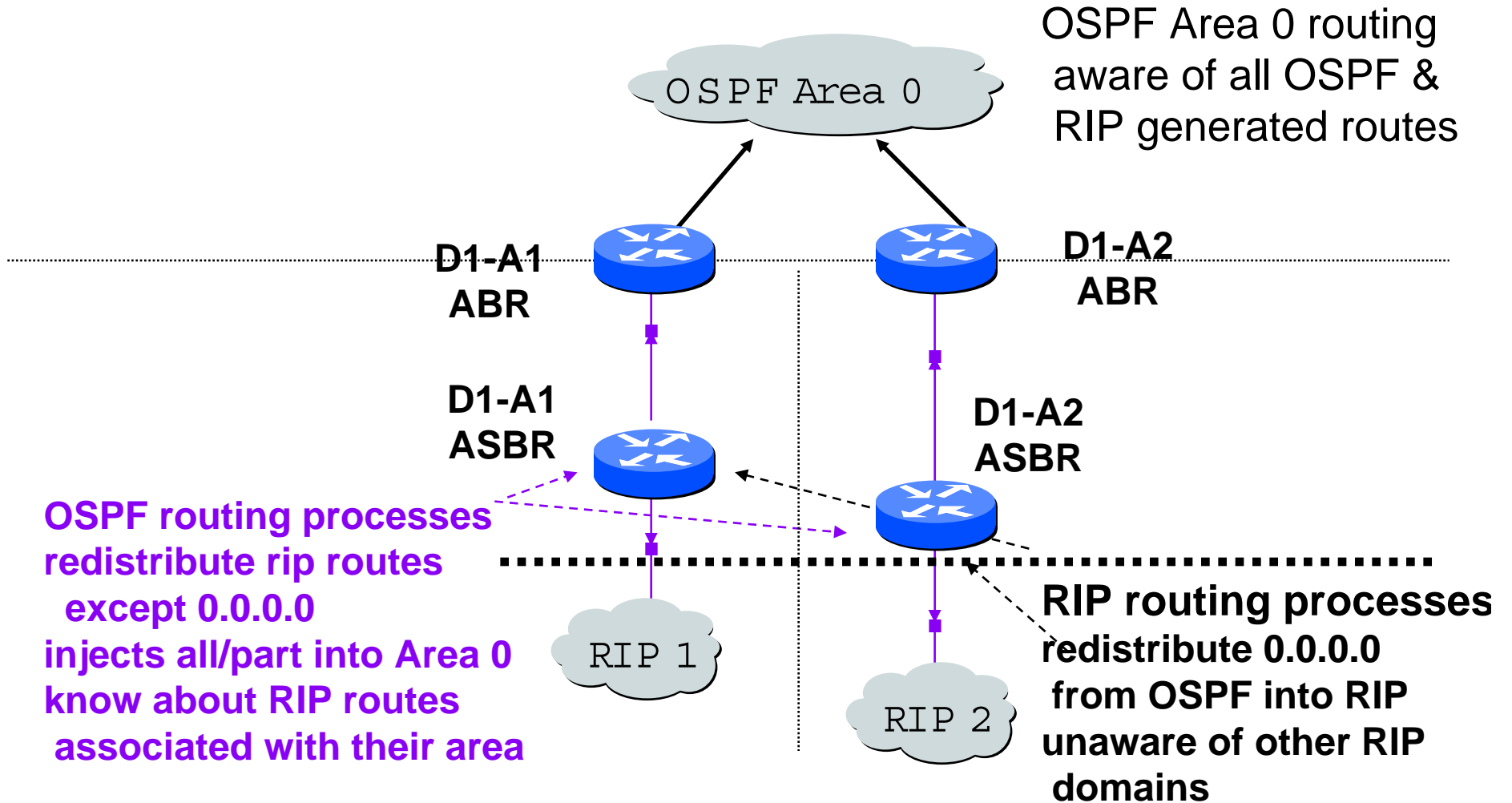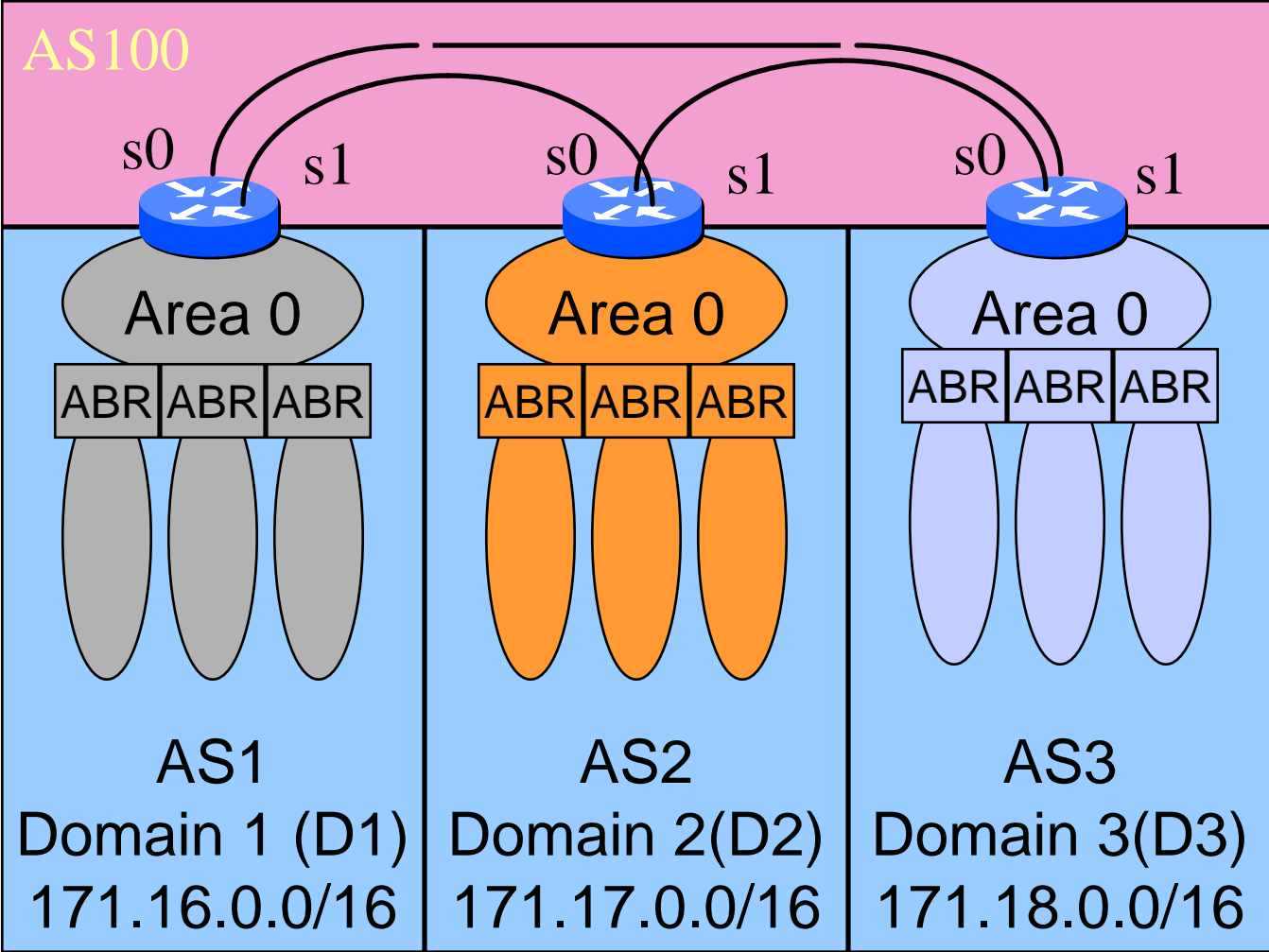
Backbones of Backbones

Default origination
Domains have clean addressing; static routes between

iBGP linkage of enterprise routing domains

eBGP linkage of enterprise routing domains

For Additional Information

- Current version of

http://www.ietf.org/internet-drafts/

  draft-ietf-ospf-deploy-00.txt

  draft-berkowitz-multirqmt-01.txt

- Contact author for seminar information

Books

- **H. Berkowitz:** *Designing Addressing Architectures for Routing and Switching (Macmillan 1998)*

- **H. Berkowitz:** *Designing Routing & Switching Architectures for Enterprise Networks (Macmillan 1999)*

- **T. Thomas:** *OSPF Network Design Solutions (Cisco Press, 1998)*

- **J. Moy:** *OSPF: Anatomy of an Internet Routing Protocol. (Addison-Wesley, 1998)*