



Interdomain routing with BGP

Issues and challenges

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Outline

- Routing in the Internet and BGP principles
- Some issues and challenges
 - Scalability of interdomain routing
 - Performance of interdomain routing
 - Security of interdomain routing

Routing in the Internet

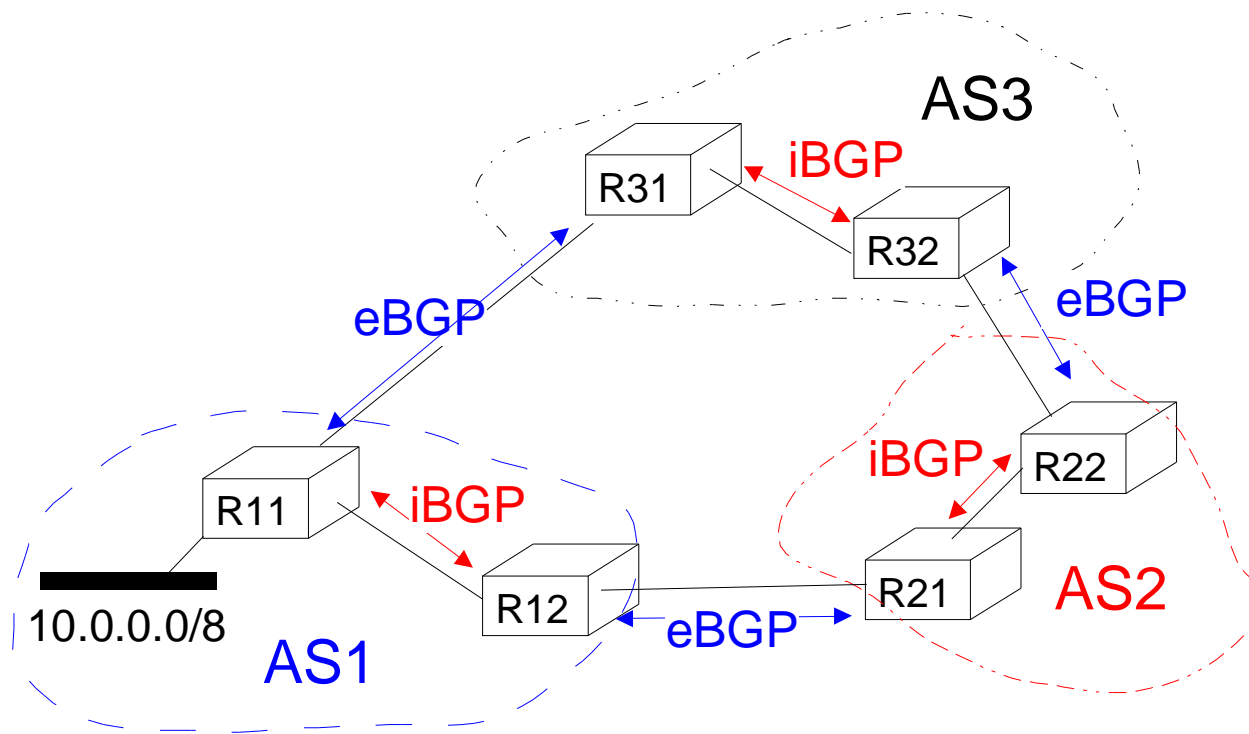
- Two different types of routing in Internet
- Intradomain routing (IGP)
 - Objective
 - ◆ select the best path towards each destination based on some metrics (e.g. Delay, bandwidth) used inside AS
- Interdomain routing (EGP)
 - Objective
 - ◆ select the best path towards each destination that is compatible with the **routing policies** of the transit ASs without knowing the topology of those transit ASs
 - Issues
 - ◆ Each AS is allowed to define its own routing policy
 - ◆ EGP should be scalable (13.000 AS, 120.000 routes)

The Border Gateway Protocol

- Objective
 - Distribute interdomain routes in a scalable manner while supporting routing policies
- Principles
 - Path-vector routing protocol
 - BGP routers exchange routing tables
 - ◆ BGP session is established over TCP connection
 - ◆ No periodic advertisement of routes as with RIP
 - ◆ routes are first advertised when BGP session is established
 - ◆ routes are updated when they change
 - ◆ routes are withdrawn when they stop being reachable
 - BGP routers use policies to filter and rank the routes sent or received

The Border Gateway Protocol (2)

- The two variants of BGP
 - **eBGP** between border routers of distinct AS
 - (full-mesh) **iBGP** between BGP routers inside AS

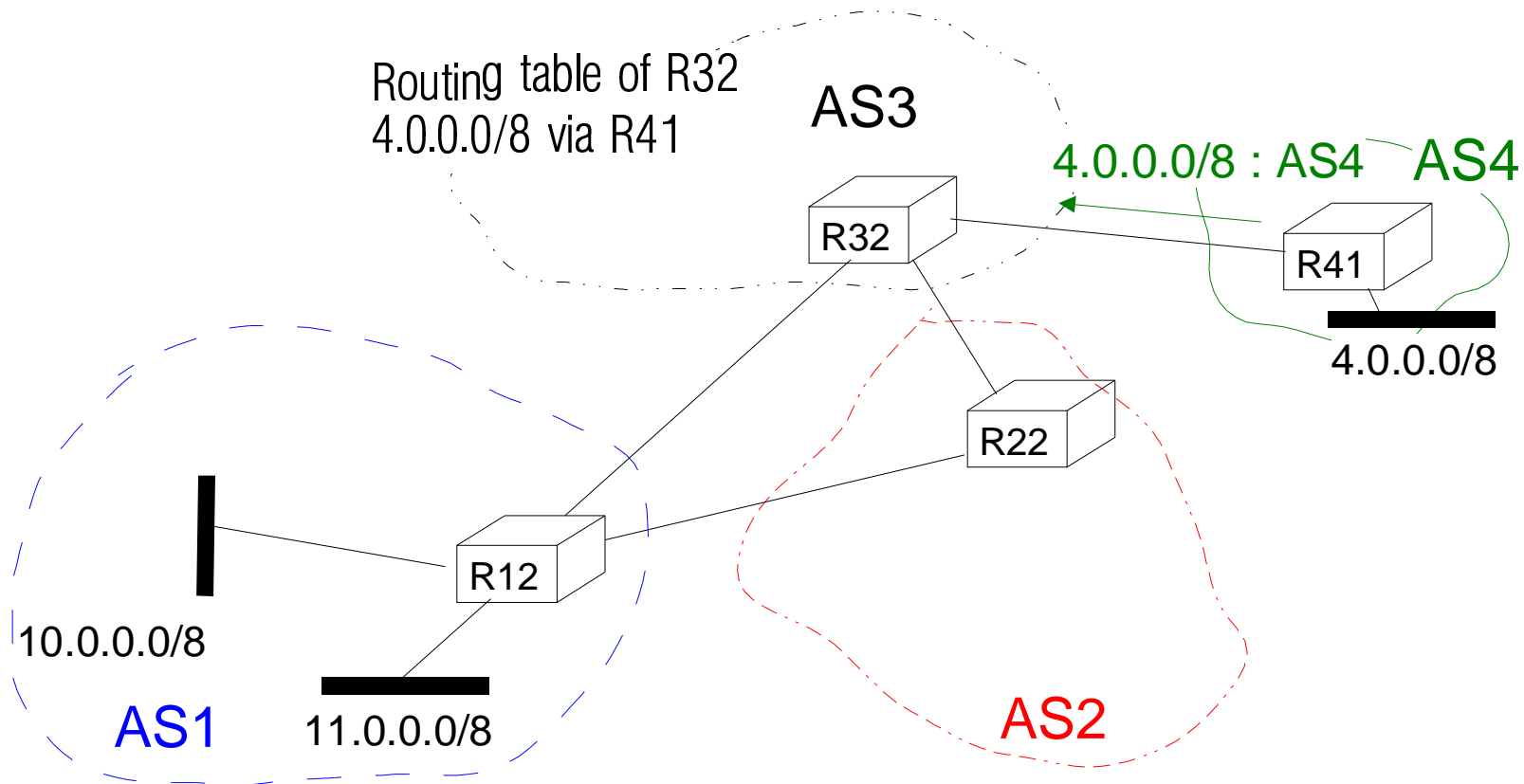


The Border Gateway Protocol (3)

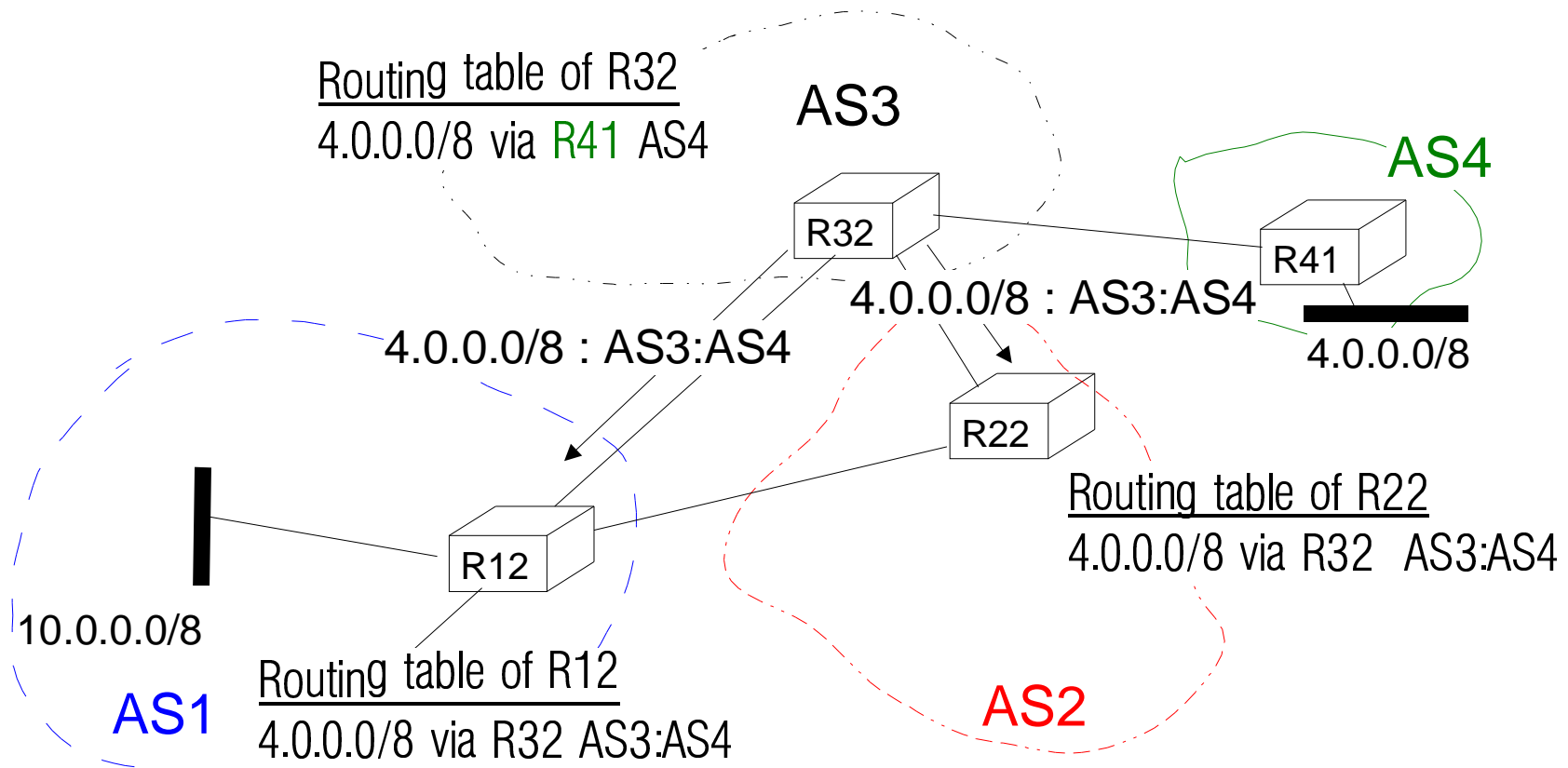
- Routes distributed in UPDATE messages
 - Contents
 - ◆ List of reachable IP prefix, List of withdrawn IP prefixes and several attributes (e.g. AS-Path)
- Processing of UPDATE message
 - For each reachable IP prefix in UPDATE
 - ◆ Add route to set of known routes towards IP prefix
 - ◆ Select **the best route** among all those routes for forwarding
 - ◆ If the best route towards this destination changed readvertise **the best route** to peers
 - For each withdrawn IP prefix in UPDATE
 - ◆ Remove route from set of known routes towards IP prefix
 - ◆ Select **the best route** among remaining routes for forwarding
 - ◆ If the best route towards this IP prefix changed readvertise **the best route** to peers

BGP : example

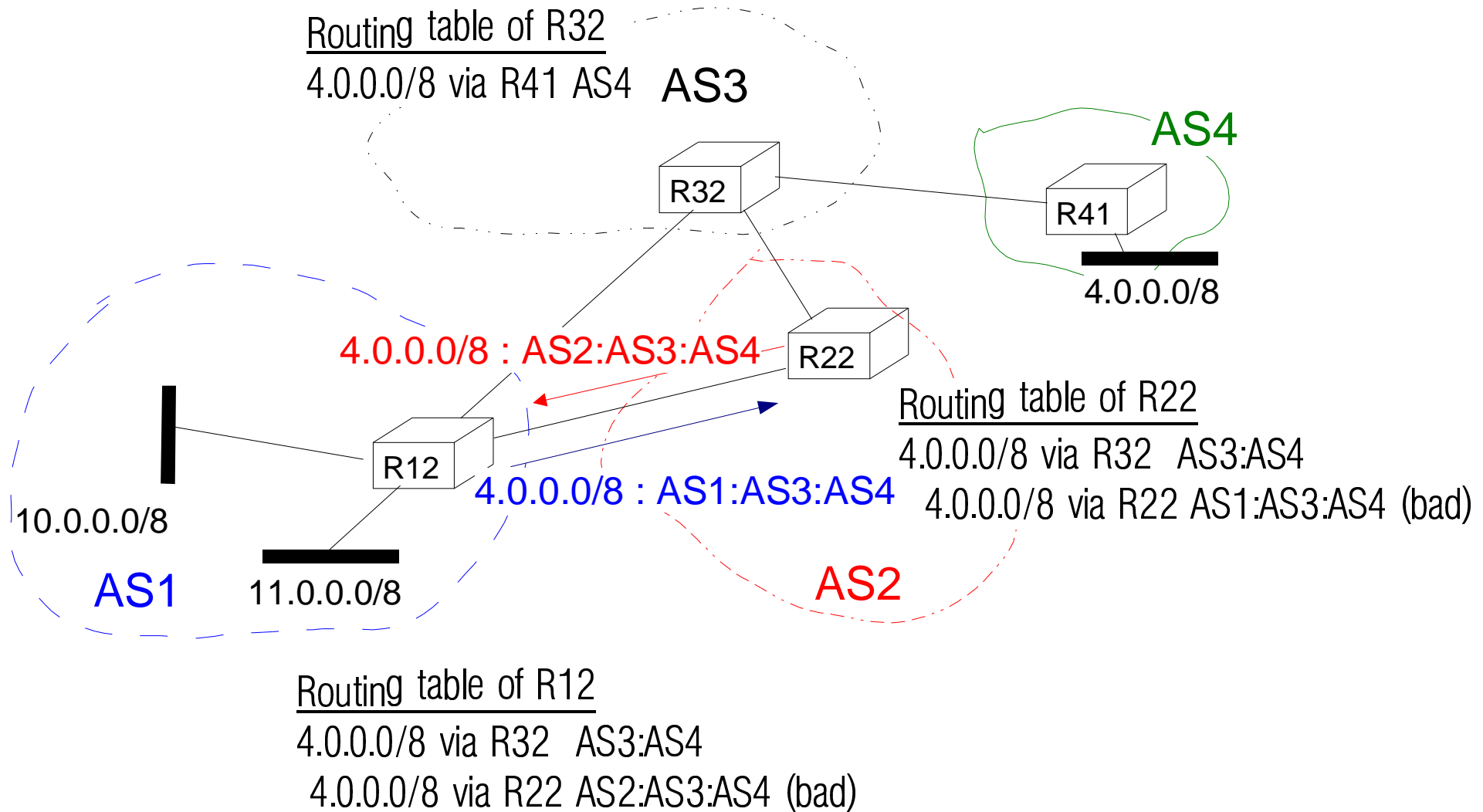
- Distribution of the route towards 4.0.0.0/8



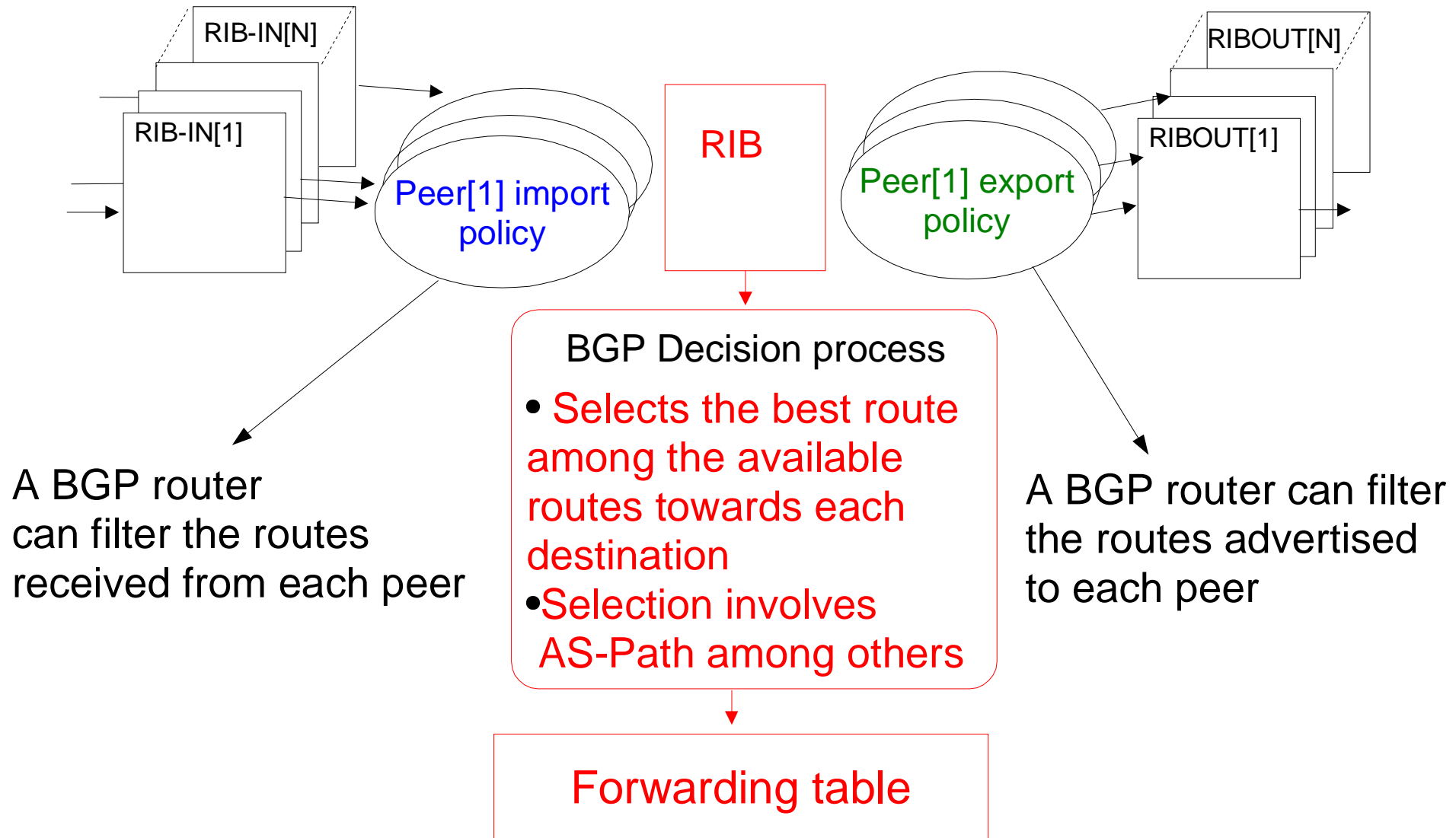
BGP : example (2)



BGP : example (3)

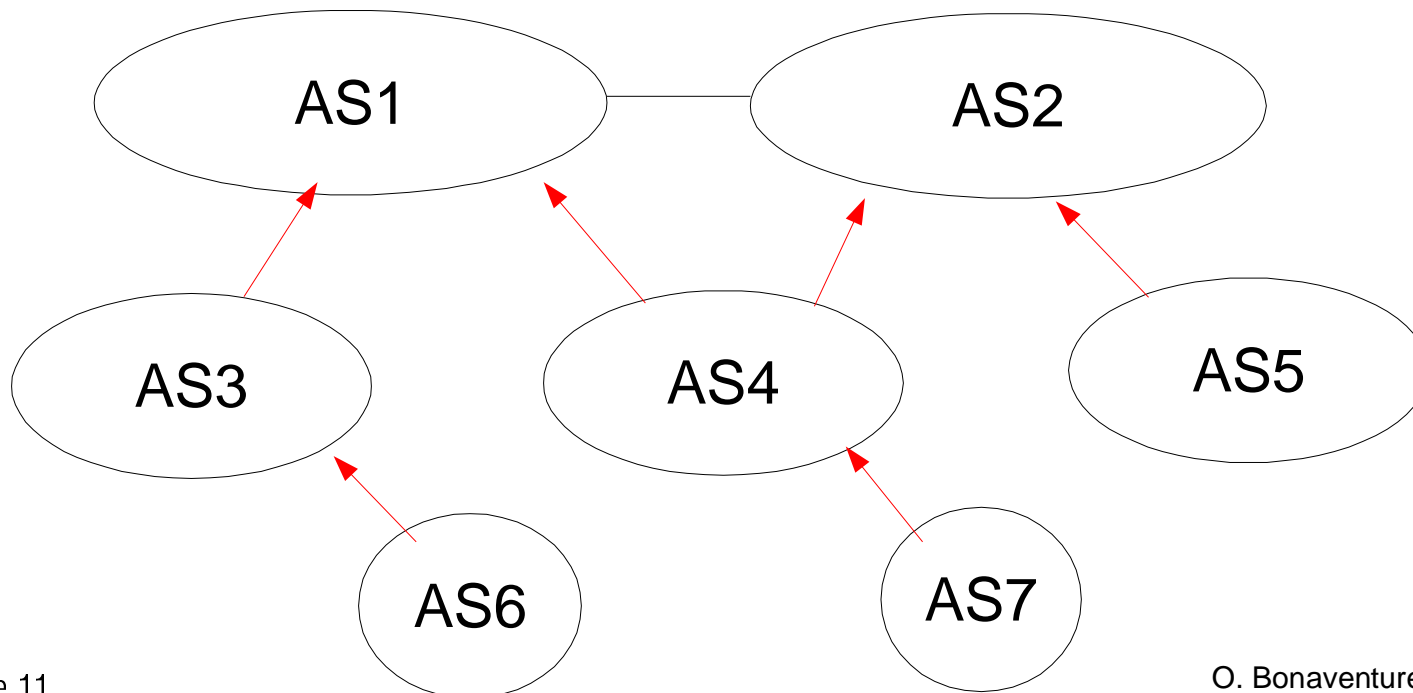


Organization of a BGP router



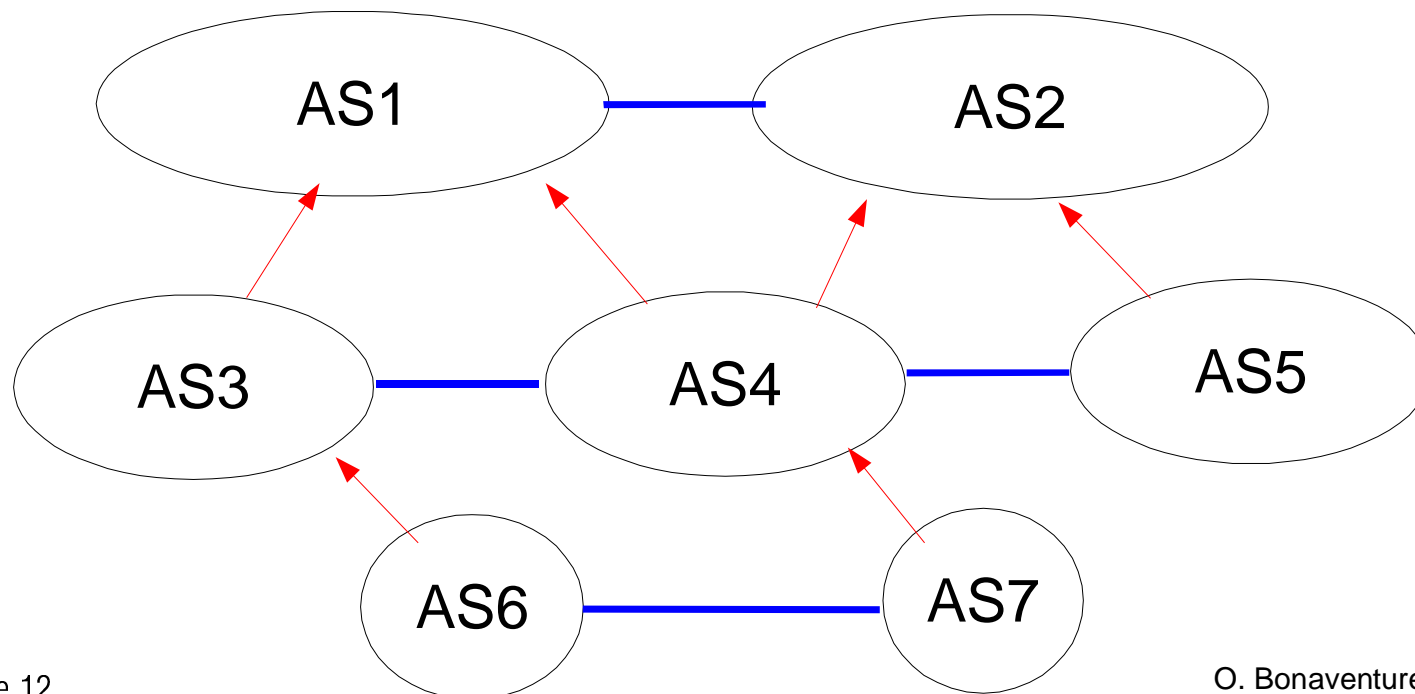
Routing policies : customer-provider

- Principle of **customer-provider peering**
 - AS_c is a smaller ISP than AS_p
 - AS_c buys transit service from AS_p
 - ◆ AS_p agrees to transmit packets from AS_c towards any destination
 - ◆ AS_p agrees to announce the routes received from AS_c



Routing policies : shared-cost

- Principle of **shared-cost peering**
 - usually used on links between Ass of same size
 - AS_x (AS_y) agrees to receive from AS_y (AS_x) packets sent towards AS_x or its direct customers
 - ◆ AS_x (AS_y) does not provide transit to AS_y (AS_x)



The Internet today

- Tier-1 ISPs

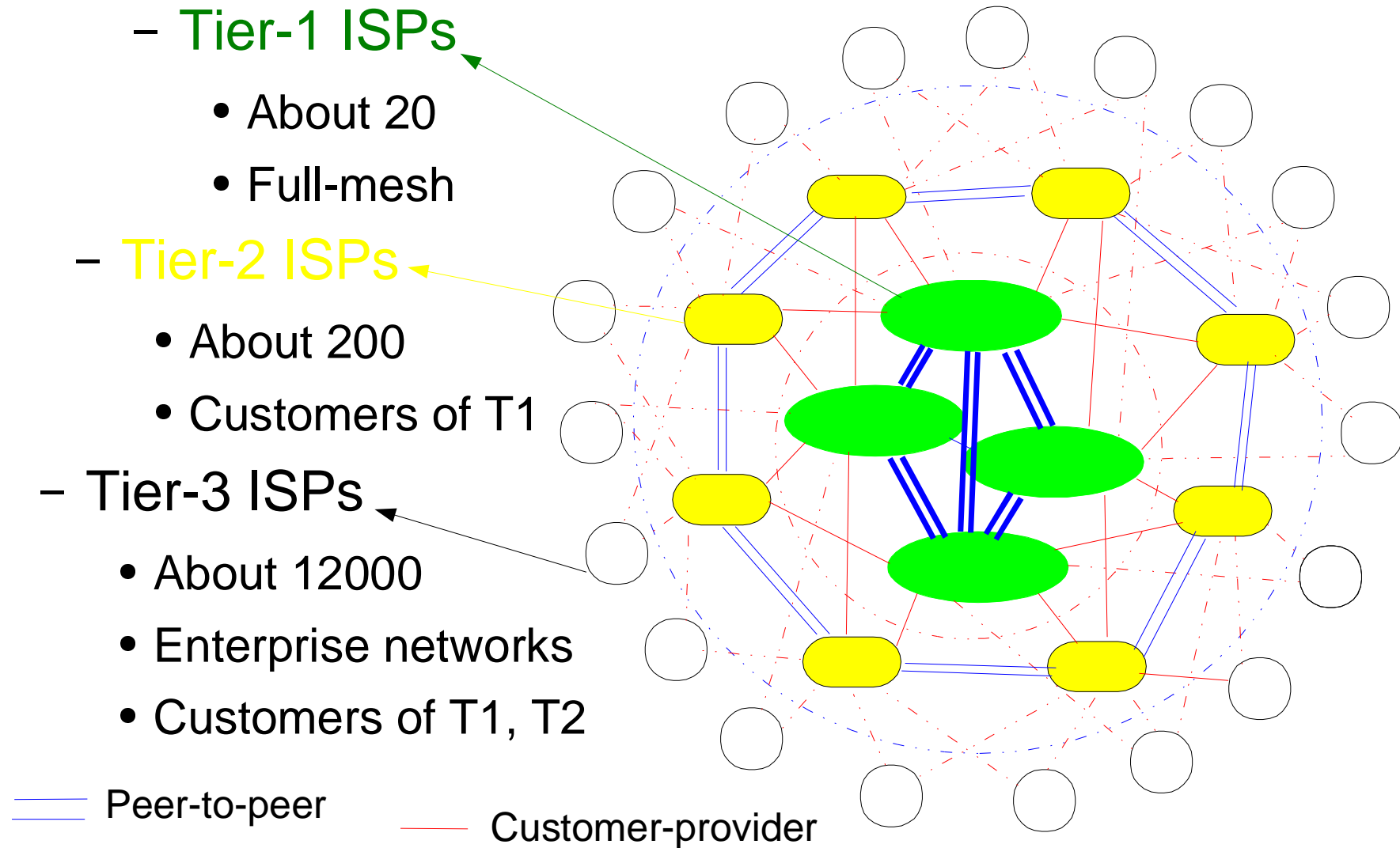
- About 20
- Full-mesh

- Tier-2 ISPs

- About 200
- Customers of T1

- Tier-3 ISPs

- About 12000
- Enterprise networks
- Customers of T1, T2

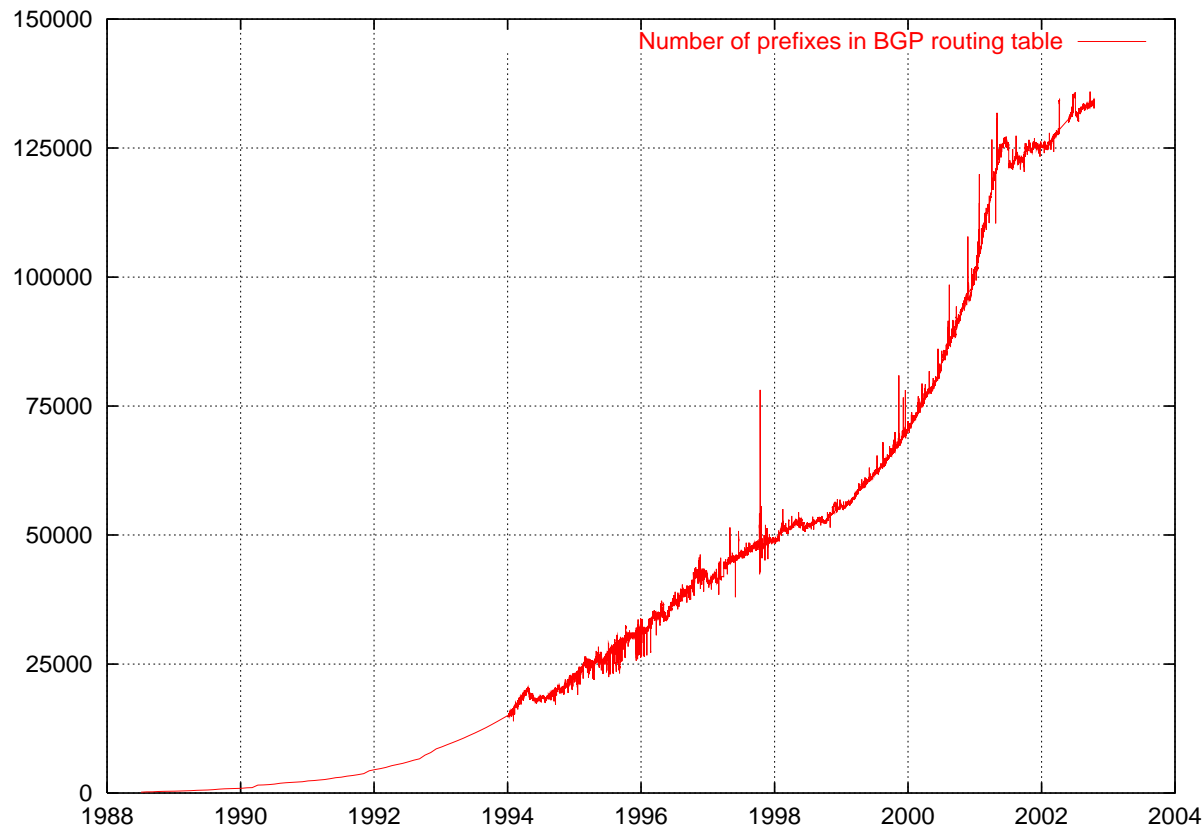


Issues and challenges

- How to sustain the growth of the Internet ?
 - In theory anyone can announce its routes with BGP
 - In practice, BGP routing tables cannot be infinite...
- How to support mission critical services in addition to the current best effort service ?
 - BGP should react quickly to link failures
 - An ISP should be able to control the flow of its interdomain traffic
- Security of interdomain routing ?

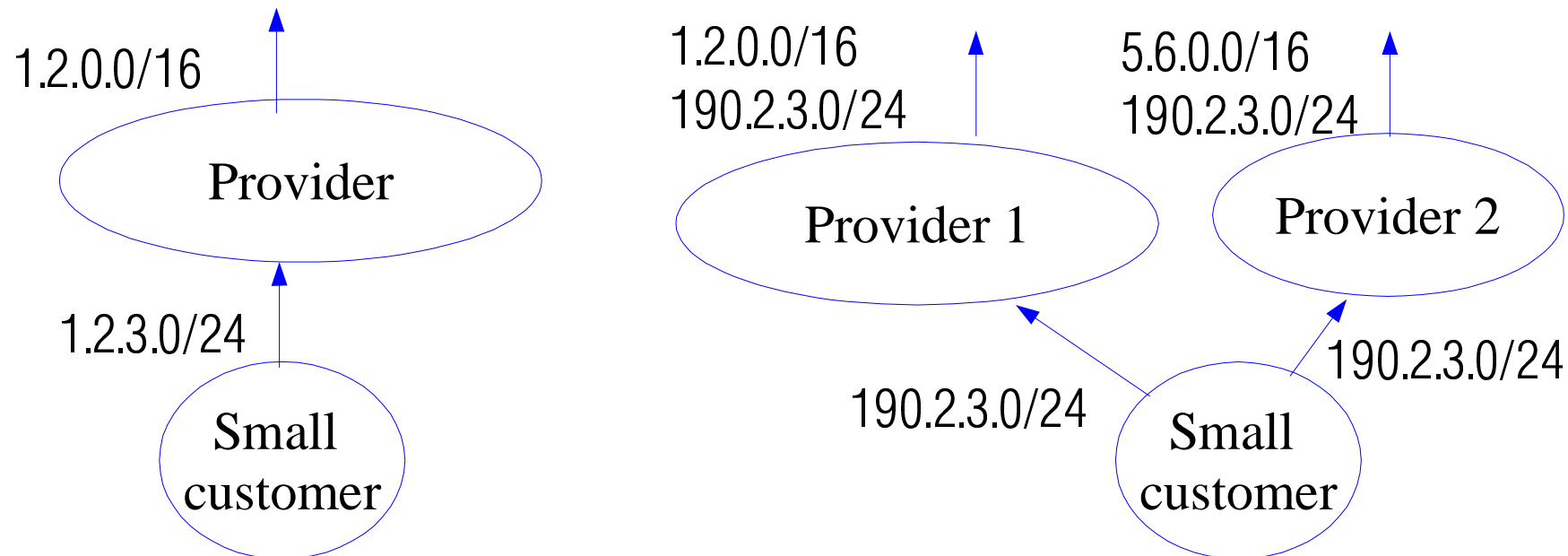
The growth of the BGP routing tables

- Evolution of the number of prefixes in BGP routing tables



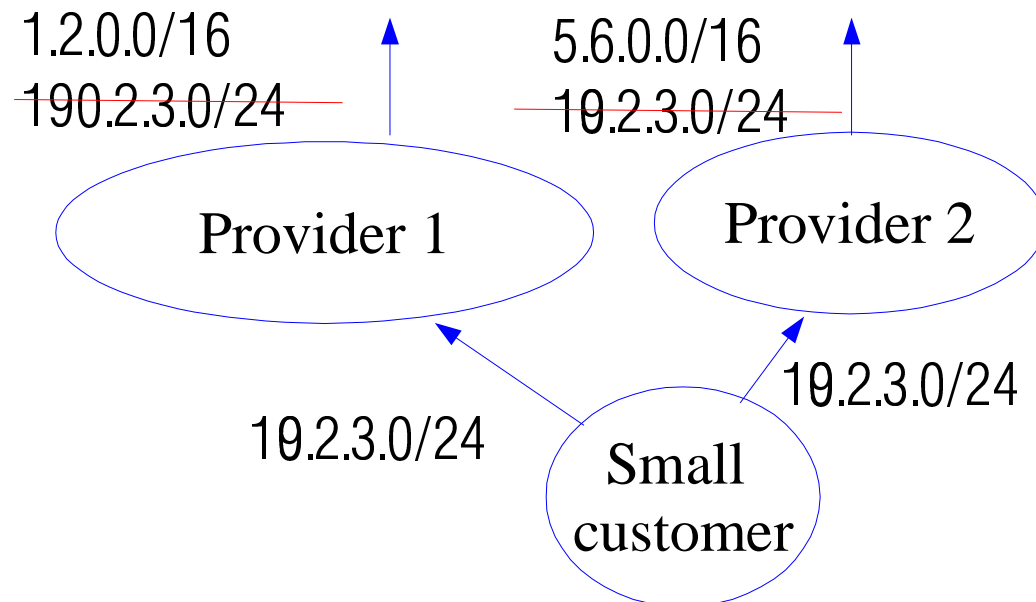
The reasons for the growth

- The Internet is growing
 - The total number of IP addresses advertised increases slowly
- The Internet is more and more fragmented
 - More and more customer networks multi-homed



How to deal with growth of BGP tables ?

- Current « solution » (aka quick hack)
 - Some ISPs filter routes towards too long prefixes
 - Consequence
 - ◆ Some routes are not distributed to the global Internet
- Towards a better solution
 - Providers should perform more aggregation

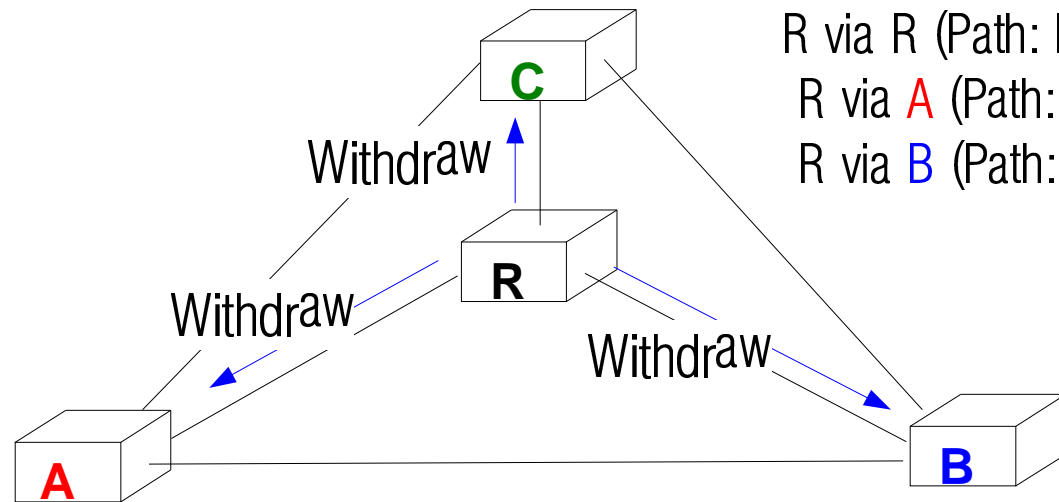


How to support mission critical services ?

- Example services
 - Voice over IP
 - Virtual Private Networks
- When an interdomain link fails, BGP should
 - Quickly announce the failure
 - Quickly distribute a new route to the destination
- Current BGP restoration times on the global Internet
 - From several tens of a second up to a few minutes and sometimes worse...

The reasons for the slow convergence

- The BGP protocol itself



Routing table of C

R via R (Path: R)

R via A (Path: A-R)

R via B (Path: C-R)

Routing table of A

R via R (Path: R)

R via B (Path: B-R)

R via C (Path: C-R)

Routing table of B

R via R (Path: R)

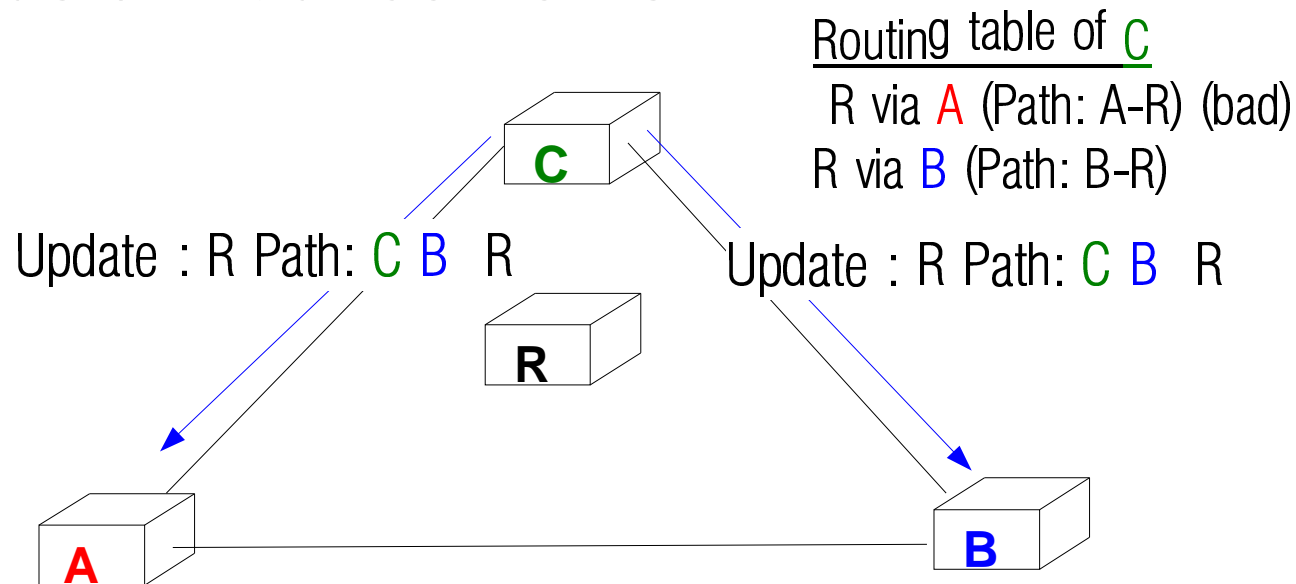
R via A (Path: A-R)

R via C (Path: C-R)

- Routers will process the withdraw and advertise alternate routes

The reasons for the slow convergence (2)

- C sends announcements



Routing table of C

R via A (Path: A-R) (bad)

R via B (Path: B-R)

Routing table of A

R via B (Path: B-R)

R via C (Path: C-R) (bad)

Routing table of B

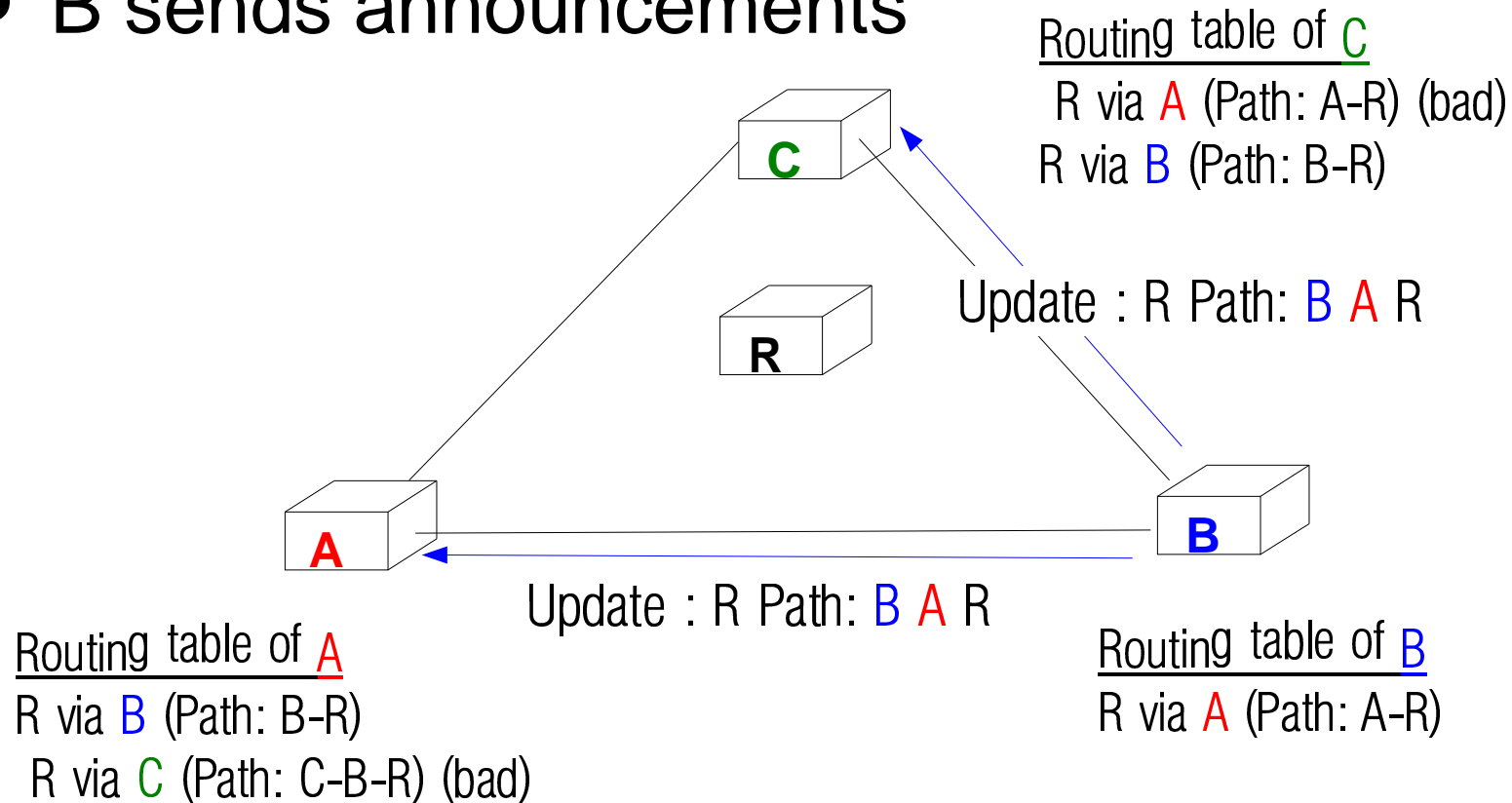
R via A (Path: A-R) (bad)

R via C (Path: C-R)

- ◆ A learns a worse (but valid) route towards R
- ◆ B learns that the route via C is a loop

The reasons for the slow convergence (3)

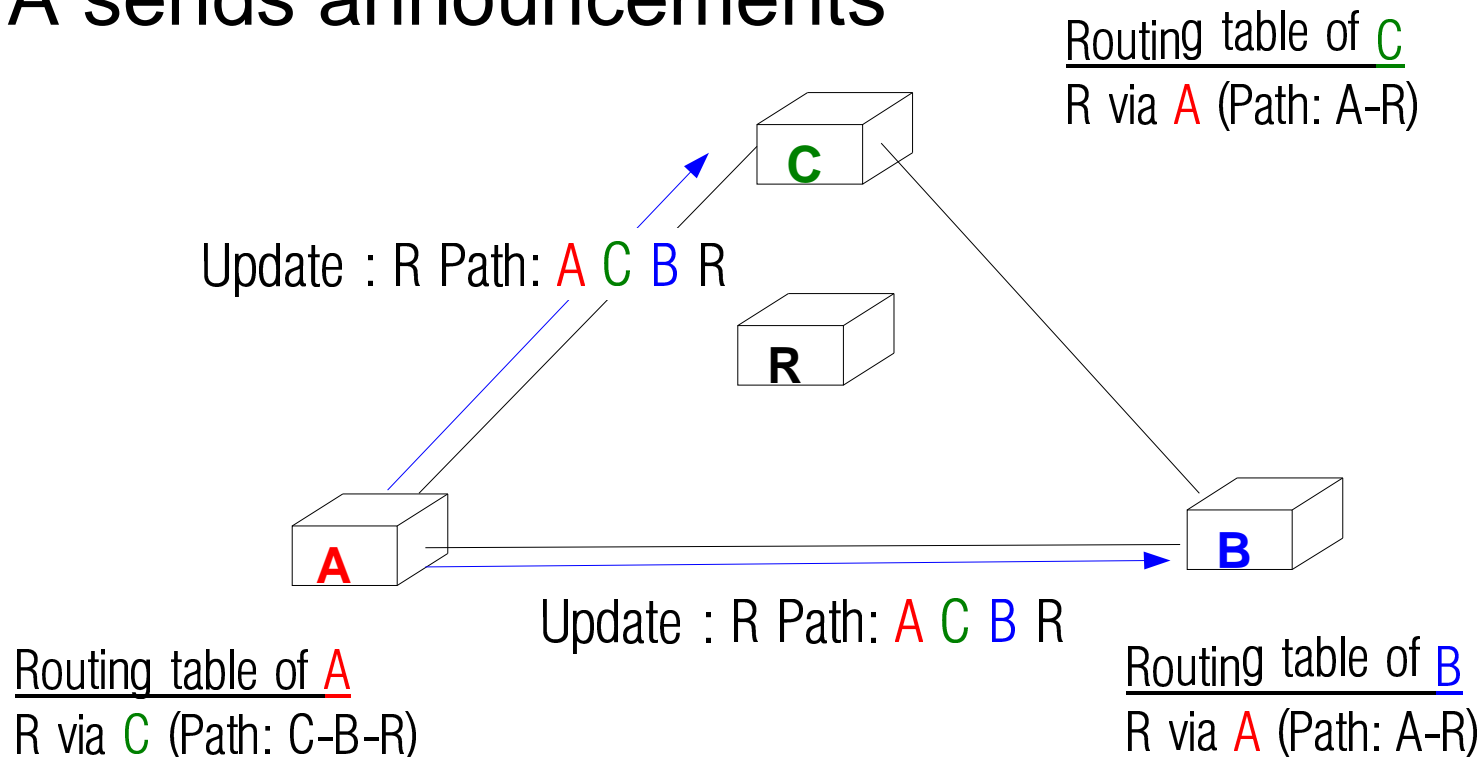
- B sends announcements



- ◆ C learns a longer (but valid) path towards R
- ◆ A learns that the route via B is a loop

The reasons for the slow convergence (4)

- A sends announcements



- ◆ C learns that route via A is a loop
 - ◆ C will withdraw its route and inform A
- ◆ B learns that route via A is a loop

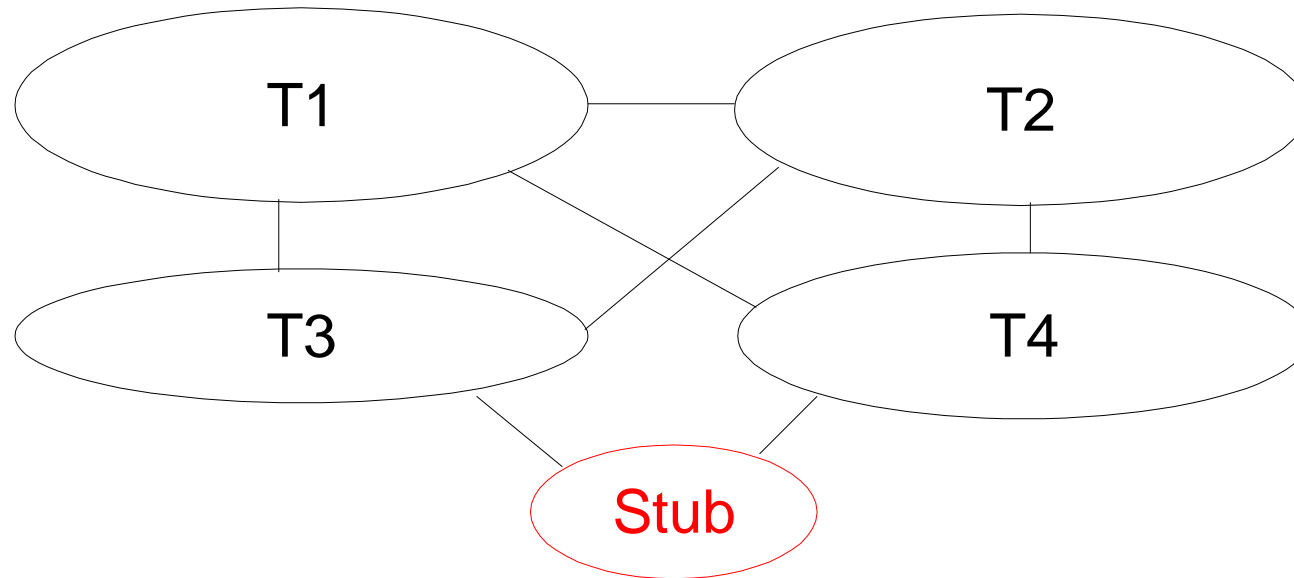
- Improving the convergence of BGP is not easy

How to control the flow of interdomain traffic ?

- Principle
 - If router x advertises a route towards destination d on link l, it implicitly agrees to forward to this destination any amount of traffic received on this link
- How to control the interdomain traffic on a link ?
 - 2 cases to consider
 - ◆ Stub domain that does not provide transit service
 - ◆ Transit domain that provides transit service to others

How to control interdomain traffic

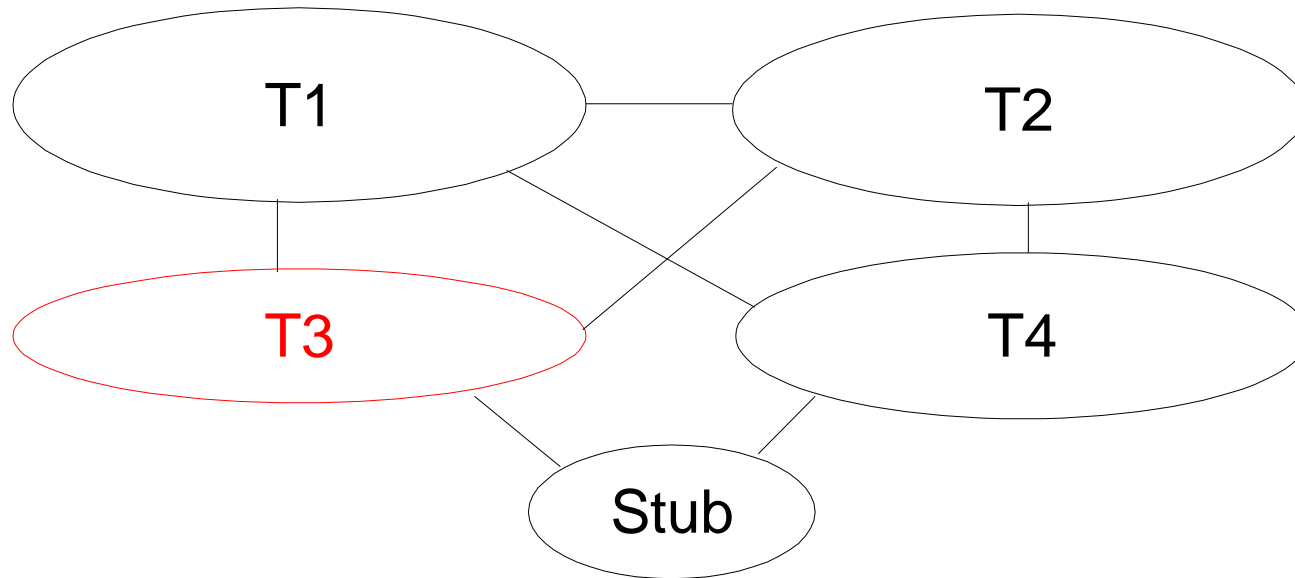
Stub domain



- Control of the outgoing traffic
 - ◆ Stub can choose any received route
- Control of the incoming traffic
 - ◆ send different route advertisements on different links
 - ◆ Only announce part of the routes from stub on a link
 - ◆ Announce some routes as « bad » routes on one link
 - ◆ Dynamic changes require transmission of new BGP msgs

How to control interdomain traffic

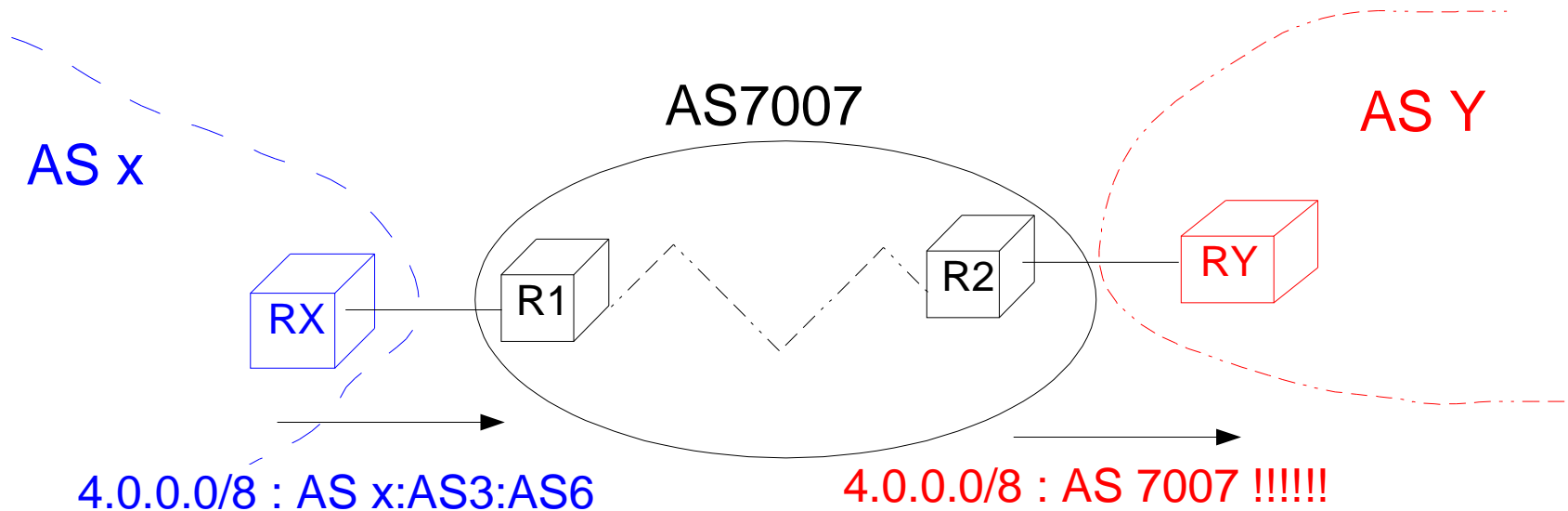
Transit domain



- Control of the outgoing traffic
 - ◆ BGP must advertise any change in the chosen route
- Control of the incoming traffic
 - ◆ send different route advertisements on different links
- Issue
 - ◆ BGP messages sent will change in function of traffic load
 - ◆ Traffic load will change in function of quality of routes

The (in)security of BGP

- The AS7007 accident



- A single configuration error in two routers
 - ◆ Two hours of disruption for large parts of the Internet
- How to deal with this problem ?
 - ◆ Filters installed by providers to detect customer errors
 - ◆ S-BGP, but requires a non-existing PKI

Research issues on interdomain routing

- How to continue to scale interdomain routing ?
- Is path vector the best technique to distribute interdomain routing information ?
 - Any new proposal should interoperate with BGP
- How to provide a faster convergence ?
 - Is one second a decent target convergence time ?
- How to secure interdomain routing ?
 - The security features must be deployable ...