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Overview of Future Internet Routing Activities

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Overview

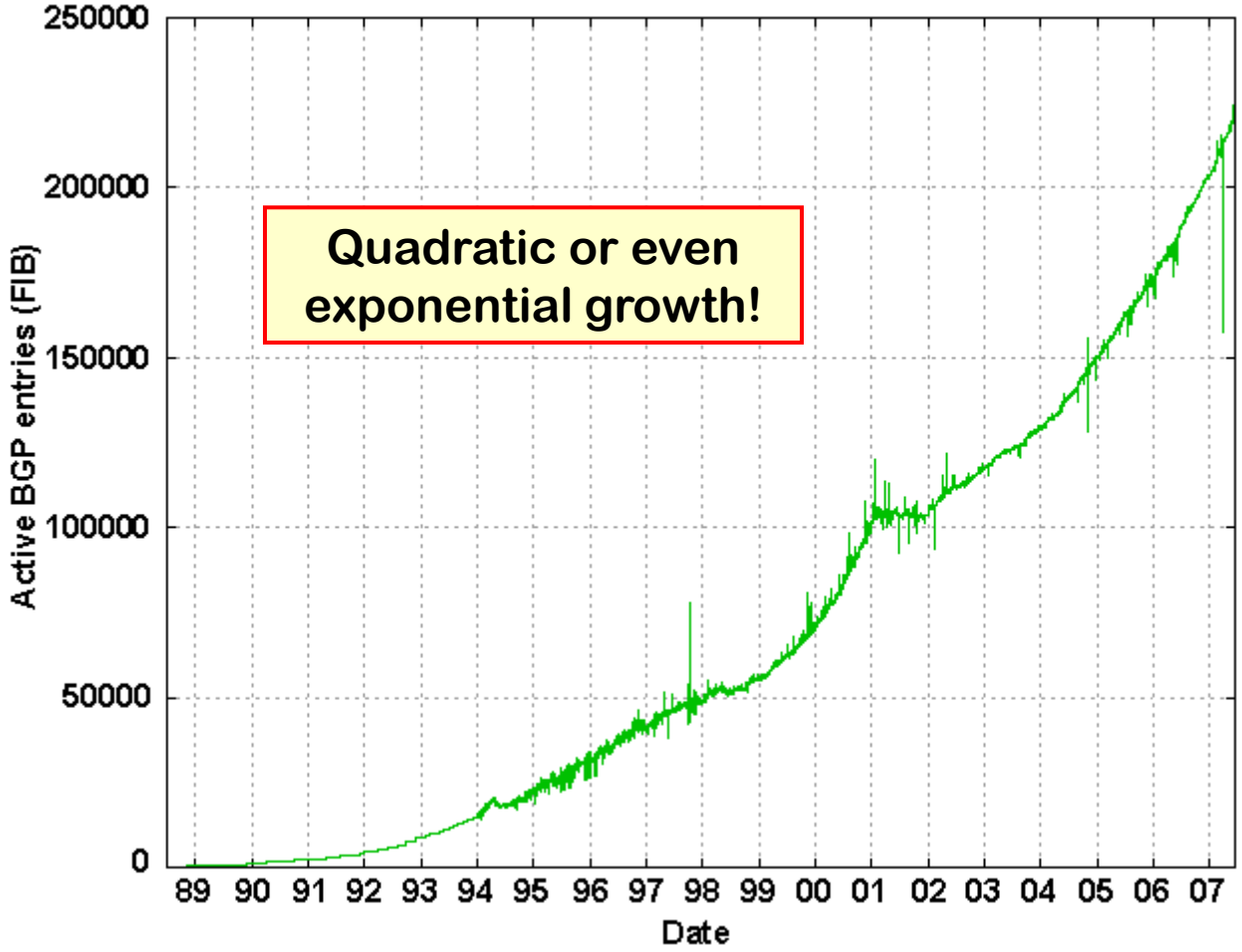
- Why does the Internet not scale?
- Locator/identifier split
- Existing protocol proposals
- Early research
- Conclusions

Internet Scalability

- DFZ (default-free zone)
  - Core of the Internet
  - No default routes for packets exist
  - Forwarding tables are large
- Provider aggregatable (PA) address space
  - Provider owns IP addresses
  - Subspace may be used by customers for the duration of their contract
  - Provider change requires renumbering
  - Aggregation of IP addresses for several customers facilitates routing scalability
- Provider independent (PI) address space
  - Customer owns IP addresses assigned by Internet registries
  - No renumbering of IP addresses necessary upon change of ISPs
  - No aggregation of IP addresses possible, prefixes require extra entries in forwarding tables $\Rightarrow$ expensive routes
- More: http://www.ripn.net:8080/nic/ripe-docs/ripe-127.txt

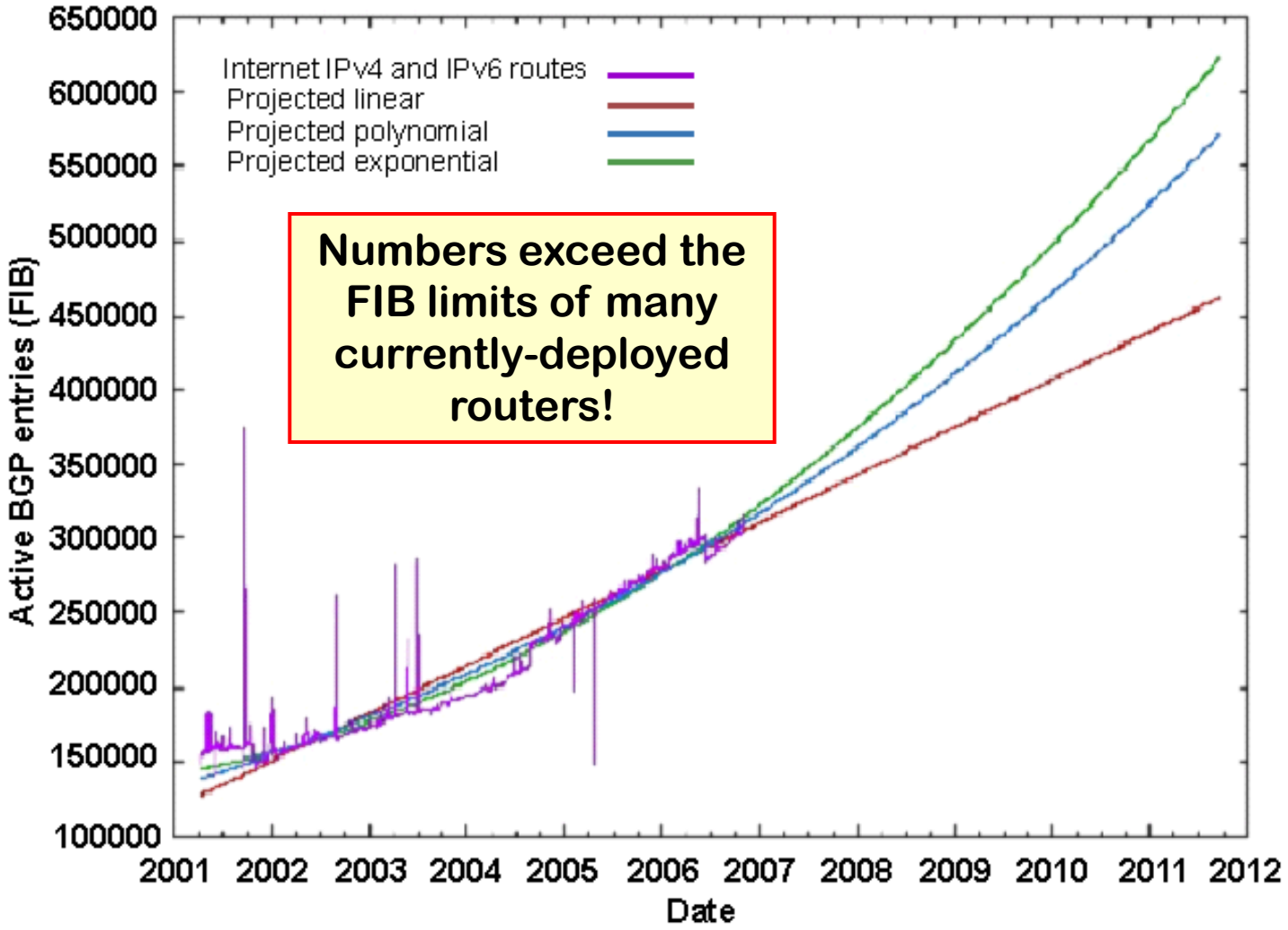
Why do we need a new Internet routing?

BGP table sizes seen at one router



[*Source*: CIDR Report IPv4 – http://www.cidr-report.org]

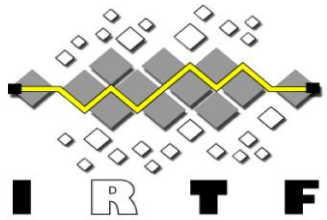
What if we do nothing? Wouldn't IPv6 help us?



[*Source*: IETF Meeting http://www.vaf.net/~vaf/apricot-plenary.pdf]

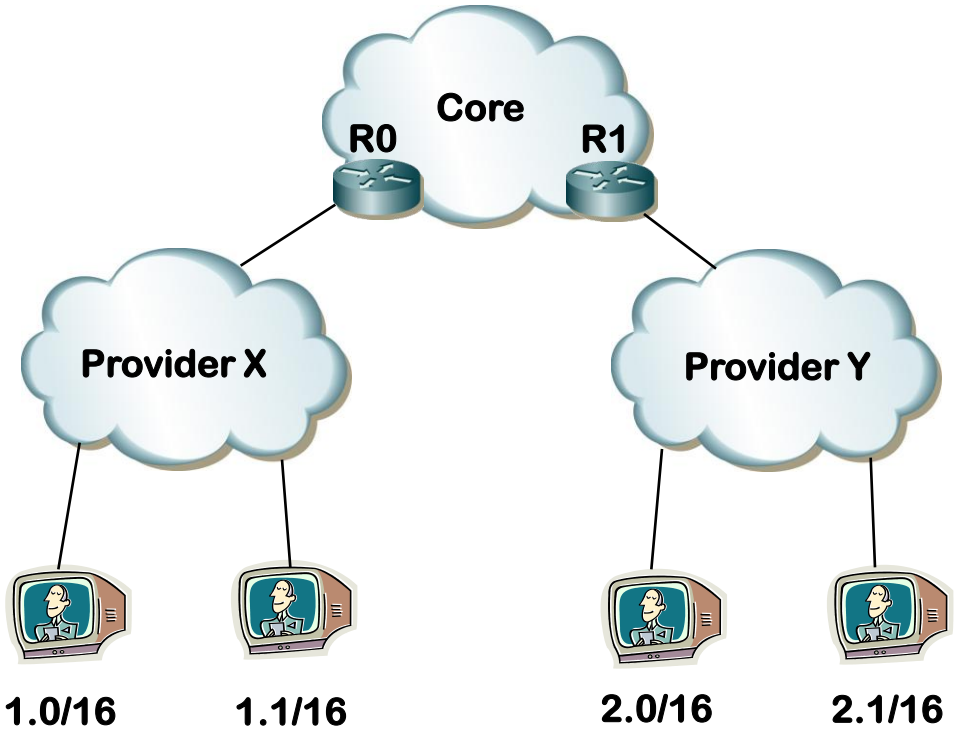
Design Goals for Scalable Internet Routing

- http://www.ietf.org/internet-drafts/draft-irtf-rrg-design-goals-01.txt
  - Improved routing scalability (required)
  - Routing security (required)
  - Deployability (required)
  - Routing quality (strongly desired)
  - Scalable support for multihoming (strongly desired)
  - Scalable support for traffic engineering (strongly desired)
  - Simplified renumbering (strongly desired)
  - Decoupling location and identification (desired)
  - Scalable support for mobility (desired)



Scalability of Internet Routing: Principle Idea

- Internet addresses initially assigned in hierarchical manner
- Address aggregation for interdomain routing
- Initially small forwarding tables

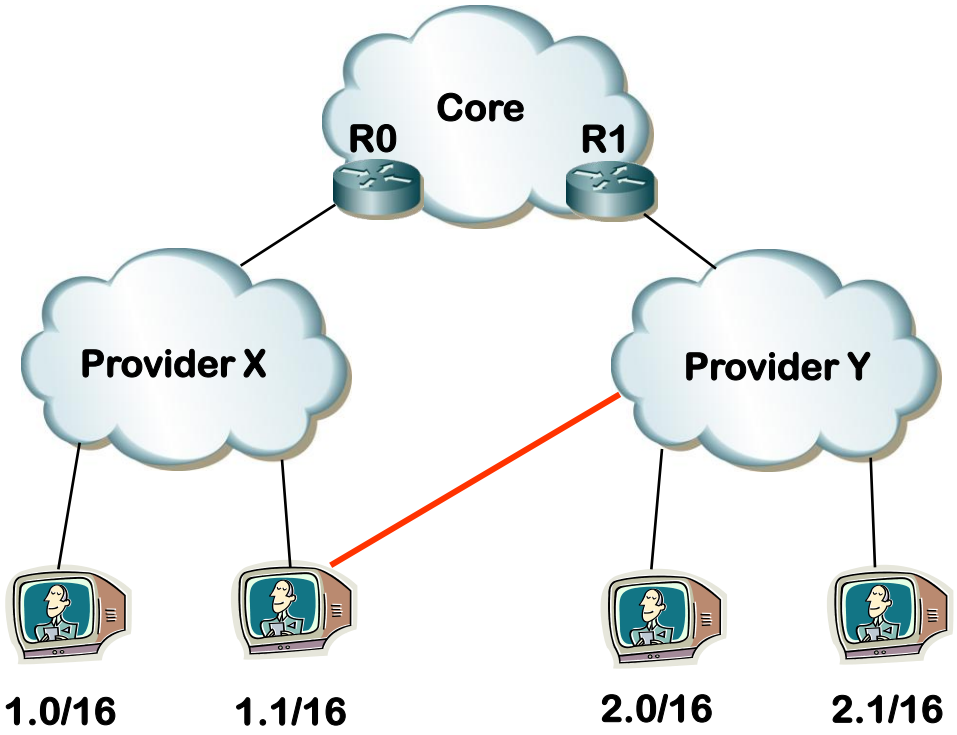


Forwarding table of R1

Prefix	NHop AS
1/8	X
2/8	Y

Scalability of Internet Routing: Multihoming & Peering

- Multihoming and peering destroy hierarchical structure
- Sizes of forwarding tables increase

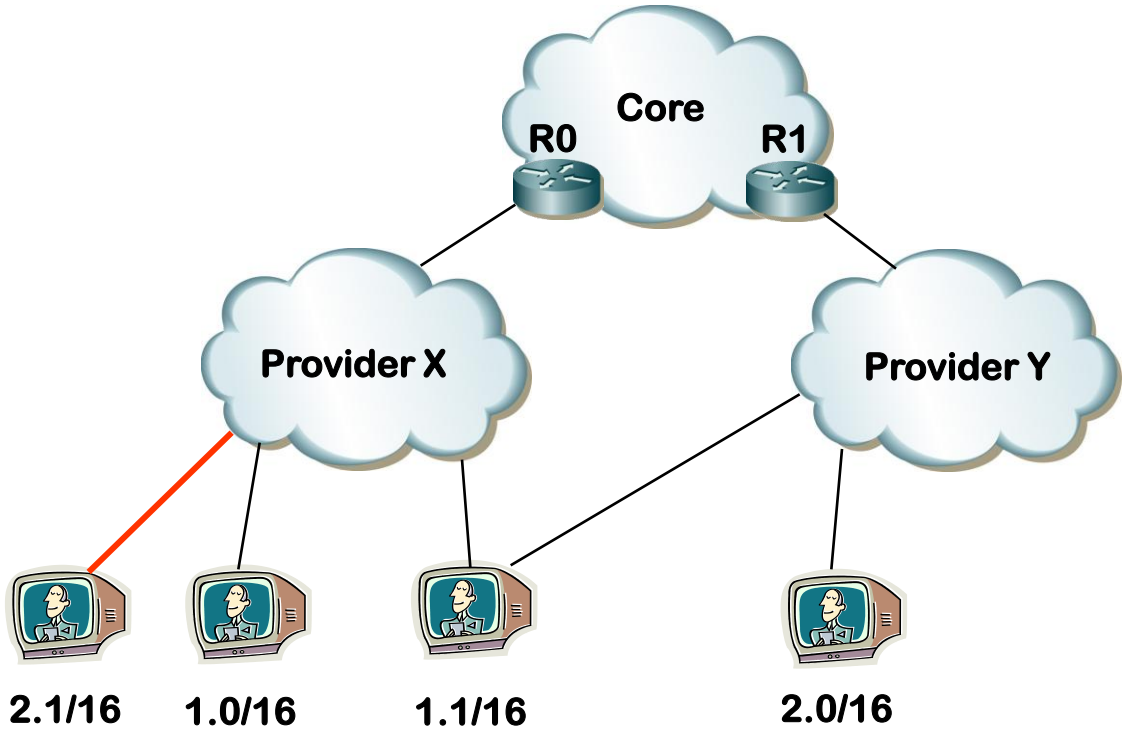


Forwarding table of R1

Prefix	NHop AS
1.0/16	X
1.1/16	Y
2/8	Y

Scalability of Internet Routing: Provider Change

- Provider changes destroy hierarchical address structure
- Sizes of forwarding tables increase

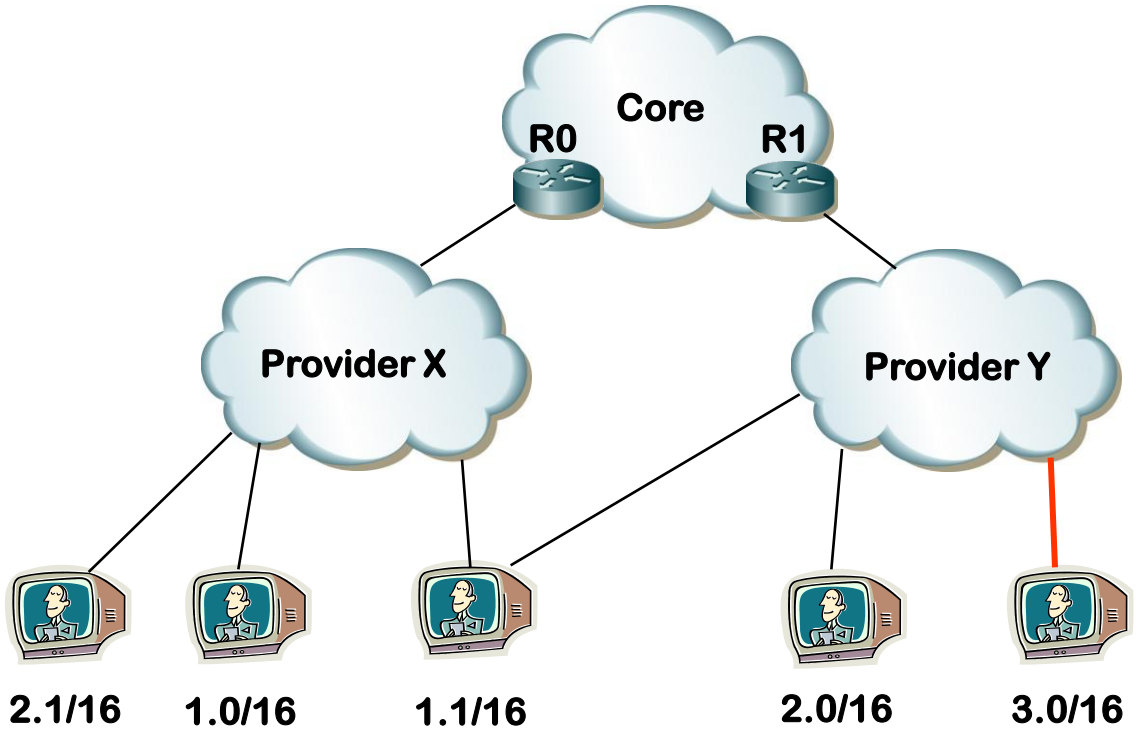


Forwarding table of R1

Prefix	NHop AS
1.0/16	X
1.1/16	Y
2.0/16	Y
2.1/16	X

Scalability of Internet Routing: Assignment of New Address Blocks

- Non-hierarchical assignments of scarce IPv4 address blocks destroy hierarchical address structure
- Sizes of forwarding tables increase



Forwarding table of R1

Prefix	NHop AS
1.0/16	X
1.1/16	Y
2.0/16	Y
2.1/16	X
3.0/16	Y

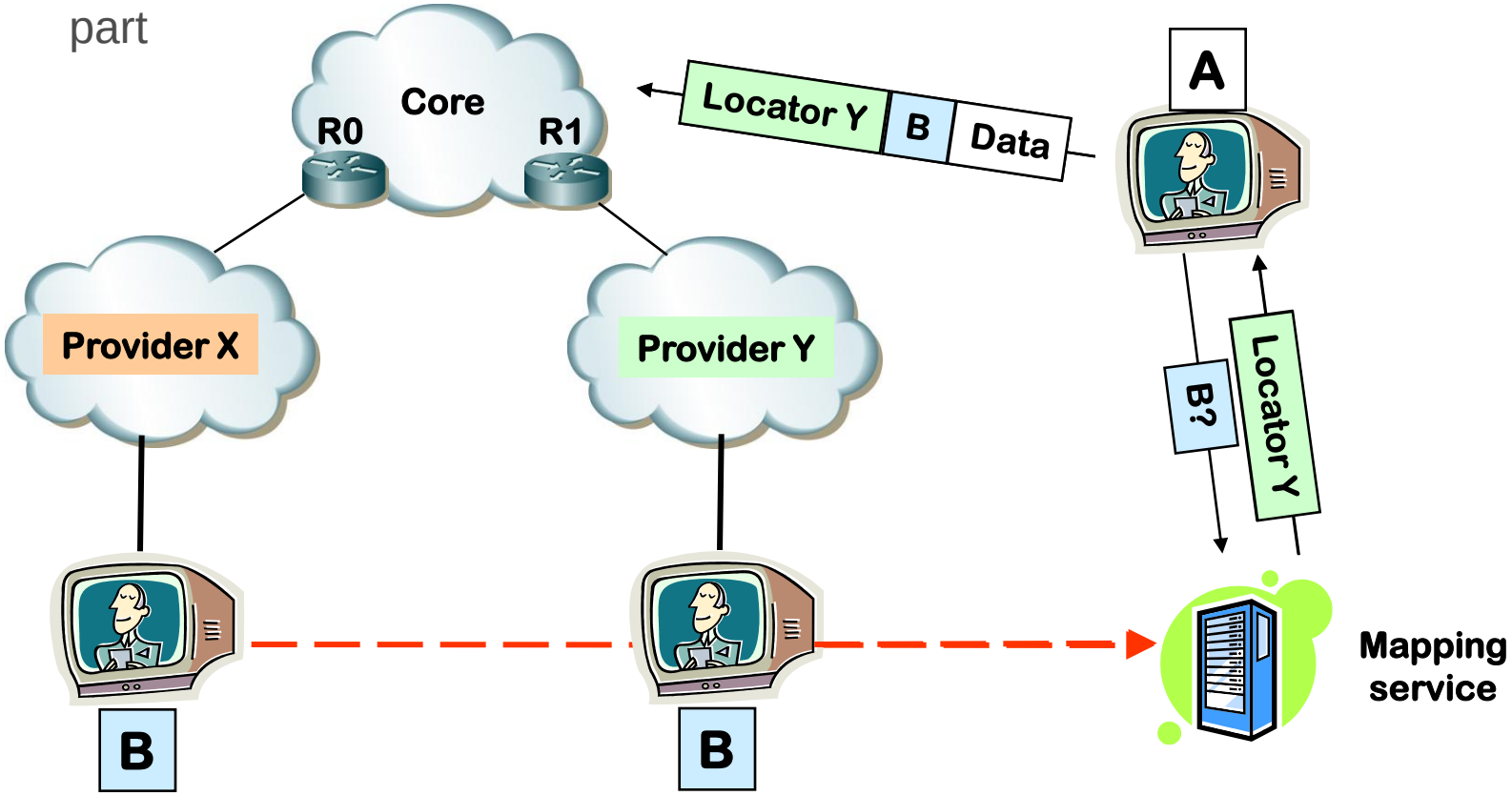
Observation: IP Addresses are Locators & Identifiers

- Causes
  - Change of the location of end systems
  - Multihoming
  - New address blocks
- Effects
  - Destroy hierarchical address structure
  - Change forwarding tables
  - Increase forwarding table sizes
- IP addresses
  - Used by forwarding to locate end systems
  - Identify end systems and must not be changed to achieve routing scalability

⇒ Combined locator and identifier function of IP addresses has negative impact on Internet scalability

Solution: Locator/Identifier Split

- Split addresses in
  - dynamically assigned locator part
  - statically assigned identifier part
- Completion of interdomain-routable addresses
  - Mapping service assigns locators to identifiers



Locator/Identifier Split: Principle Idea

- Address aggregation improves scalability of mapping service (MS)
- Table size of MS not required to be small; intelligent implementation
  - Similarly to DNS
  - Using DHTs

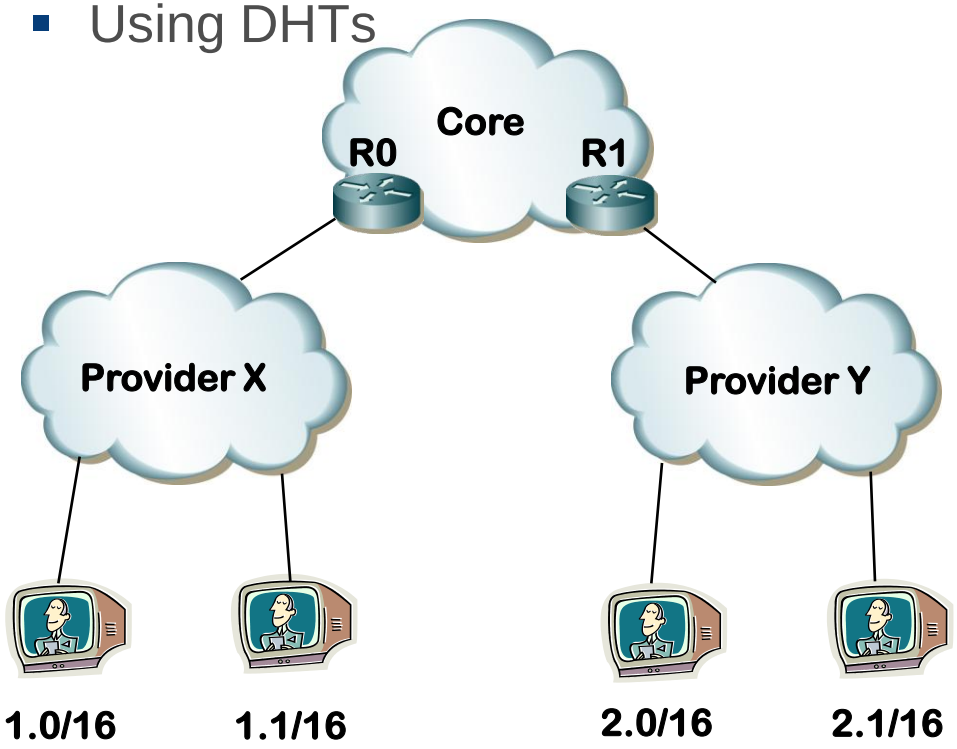


Table of mapping service

Identifier prefix	Locator
1/8	X
2/8	Y

Locator/Identifier Split: Multihoming & Peering

- Mapping service can be used for traffic egineering
  - Answer request with X or Y depending on source address of request

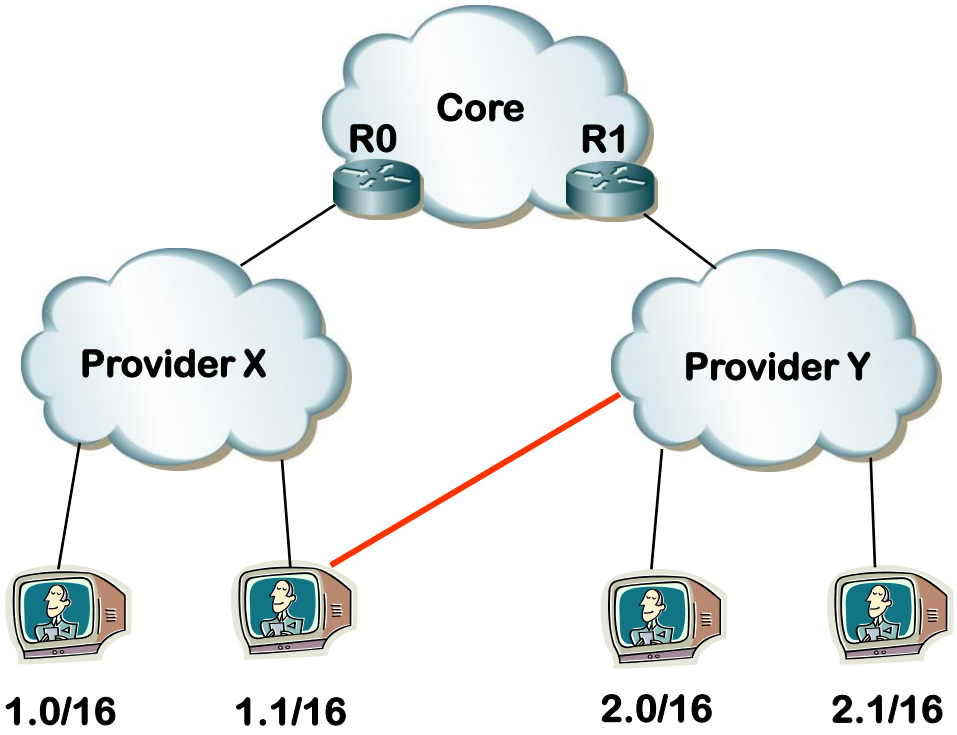


Table of mapping service

Identifier prefix	Locator
1.0/16	X
1.1/16	X, Y
2/8	Y

Locator/Identifier Split: Provider Change

- Provider changes invisible to Internet-internal routing structure
- Just mapping service changes

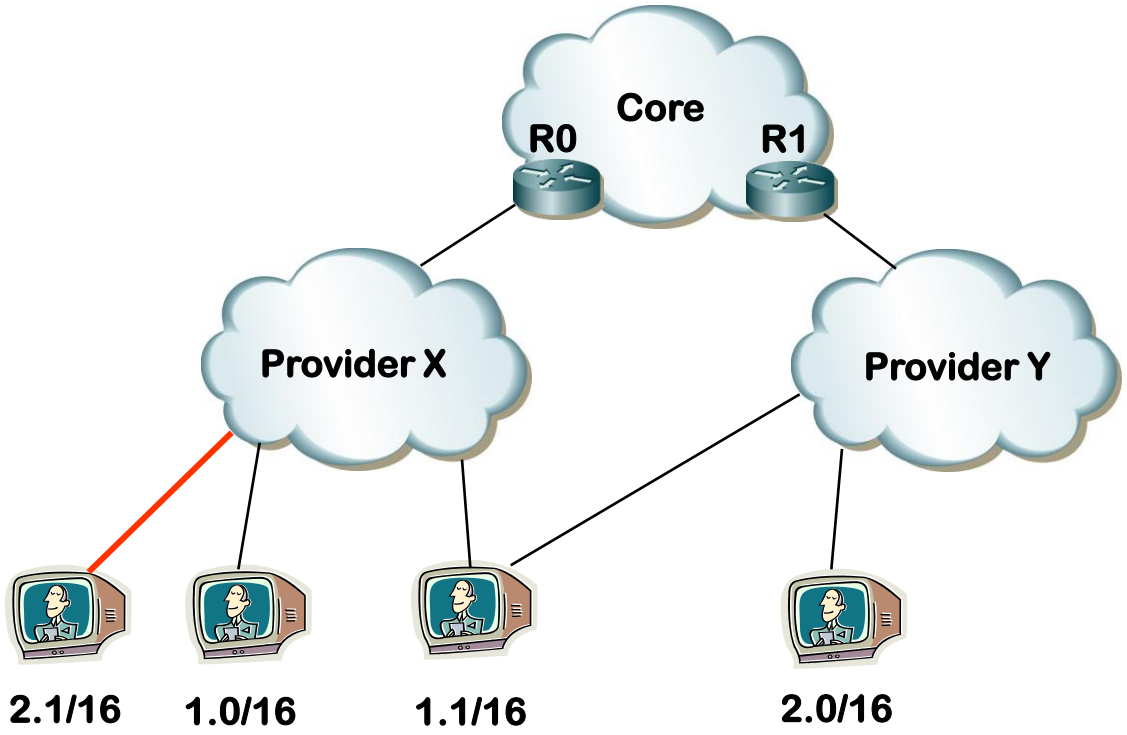


Table of mapping service

Identifier prefix	Locator
1.0/16	X
1.1/16	X, Y
2.0/16	Y
2.1/16	X

Locator/Identifier Split: Assignment of New Address Blocks

- Provider changes invisible to Internet-internal routing structure
- Just mapping service changes

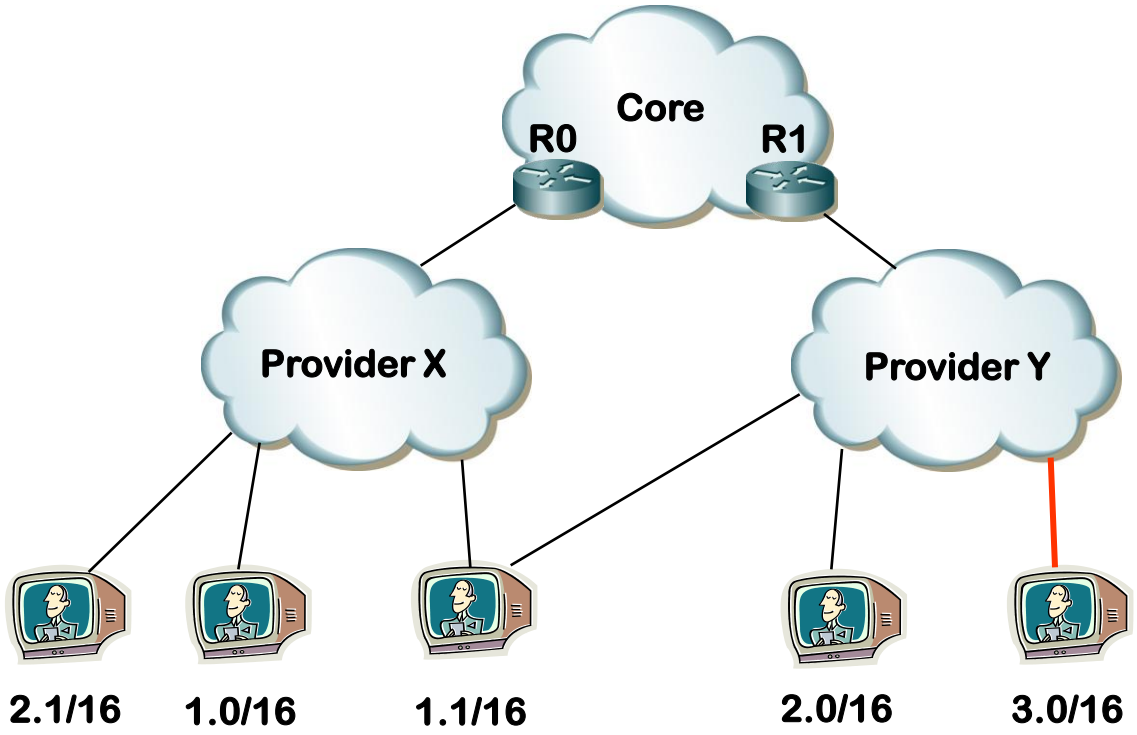
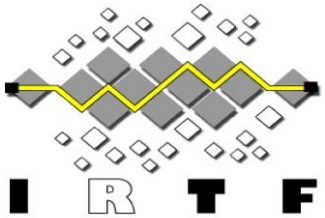


Table of mapping service

Identifier prefix	Locator
1.0/16	X
1.1/16	X, Y
2.0/16	Y
2.1/16	X
3.0/16	Y

Protocol Proposals Implementing Locator/Identifier Split



- Some recent approaches (not a complete list!)
  - Locator/ID Separation Protocol (LISP)
    http://www.ietf.org/internet-drafts/draft-farinacci-lisp-01.txt
  - A Proposal for Scalable Internet Routing & Addressing (eFIT)
    http://www.ietf.org/internet-drafts/draft-wang-ietf-efit-00.txt
  - The IPvLX Architecture
    http://www.ietf.org/internet-drafts/draft-templin-ipvlx-08.txt
  - Internet Vastly Improved Plumbing (IVIP)
    http://www.firstpr.com.au/ip/ivip/
  - HLP: A Next Generation Interdomain Routing Protocol
    http://www.cs.ucl.ac.uk/staff/M.Handley/papers/hlpsigcomm.pdf
  - Scaling IP Routing with the Core Router-Integrated Overlay (CRIO)
    http://www.cs.cornell.edu/People/francis/icnp06-crio.pdf
- More at the next meeting of the RRG, July 27th, collocated with IETF-69:
  http://www3.tools.ietf.org/group/irtf/trac/wiki/RoutingResearchGroup

Early Research

- Bruno Quoitin, Luigi Iannone, Cédric de Launois, and Olivier Bonaventure: Evaluating the Benefits of the Locator/Identifier Separation, MobiArch Workshop at Sigcomm 2007, http://inl.info.ucl.ac.be/system/files/MobiArch07-CRV.pdf
- Luigi Iannone and Olivier Bonaventure: Locator/ID Separation: Study on the Cost of Mappings Caching and Mappings Lookups, technical report, http://inl.info.ucl.ac.be/system/files/TechReport-LISP-Cost.pdf
- Daniel Massey, Lan Wang, Beichuan Zhang, and Lixia Zhang: A Scalable Routing System Design for Future Internet, IPv6 Workshop at Sigcomm 2007, http://www.cs.ucla.edu/~lixia/papers/07SIG_IP6WS.pdf
- Olivier Bonaventure: Reconsidering the Internet Routing Architecture, Internet Draft, http://www.ietf.org/internet-drafts/draft-bonaventure-irtf-rrg-rira-00.txt

Conclusions

- Scalability problems in current interdomain routing recognized
- Routing research group (RRG) in IRTF keeps track of that issue
- Locator/identifier split seems to be one solution
- Several protocol proposals based on this concept
- Clean slate has more freedom!
- New research opportunities
  - Scalability
  - Architectures for mapping services
  - Caching performance
  - Traffic engineering
  - Resilience
- Just the beginning of future Internet routing!