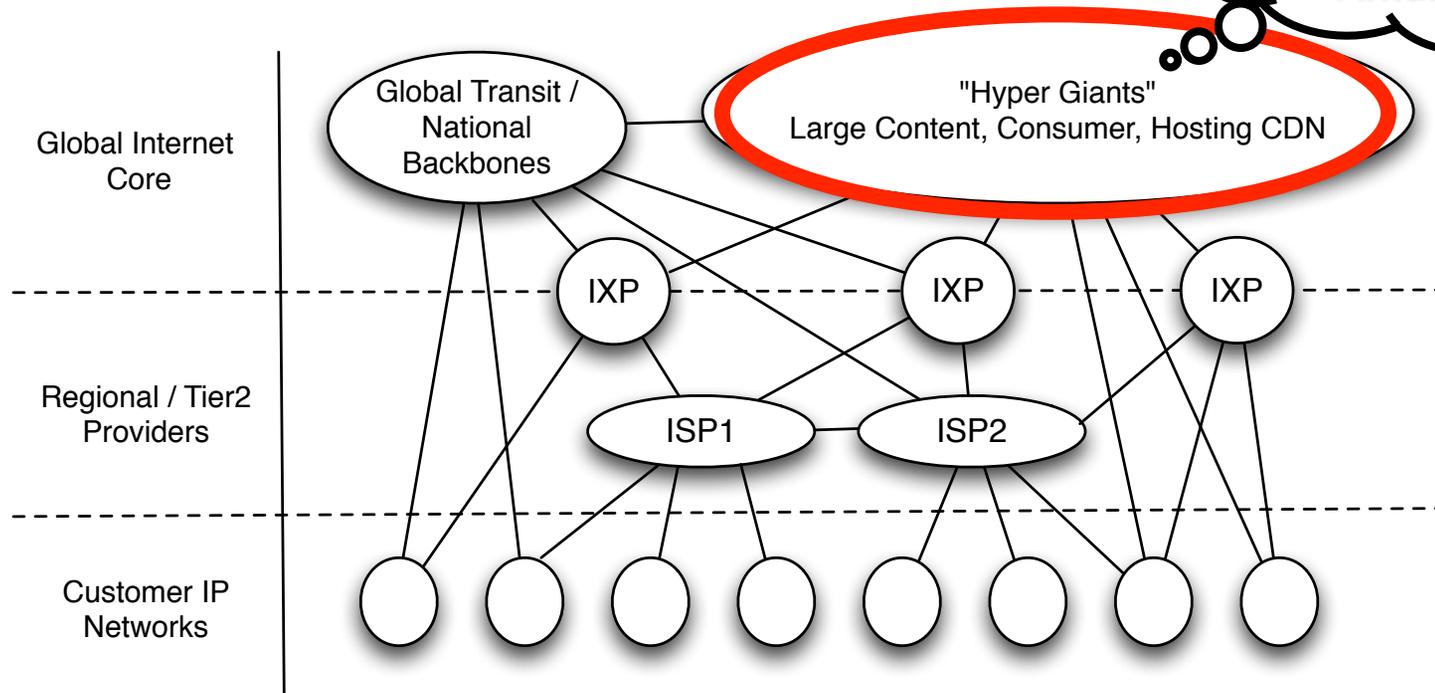


Improving Performance and Cost in a Hyperconnected World

Georgios Smaragdakis

The New Internet



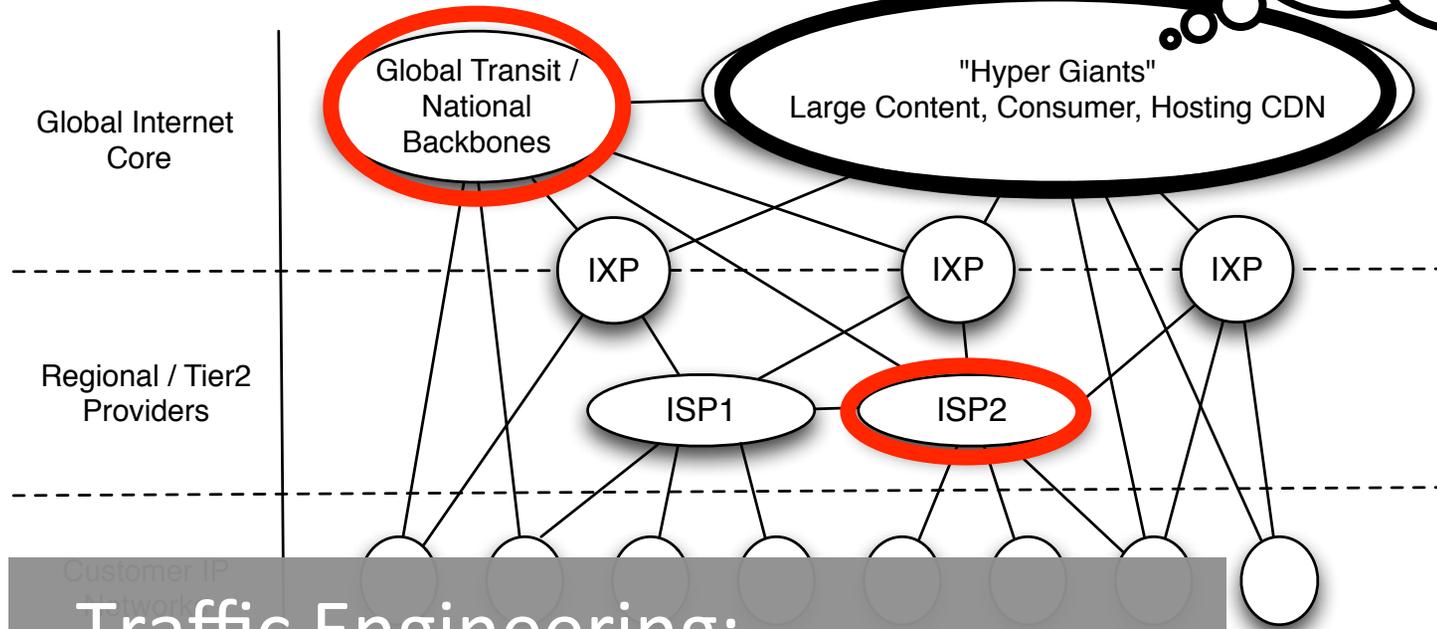
Source: Arbor Networks 2010

New core of interconnected content and consumer networks [1,2]
→ "Hyperconnectivity"

[1] "Internet Interdomain Traffic", Labovicz et al. SIGCOMM 2010

[2] "Anatomy of a large European IXP", Ager et al. SIGCOMM 2012

The New Internet



Traffic Engineering:

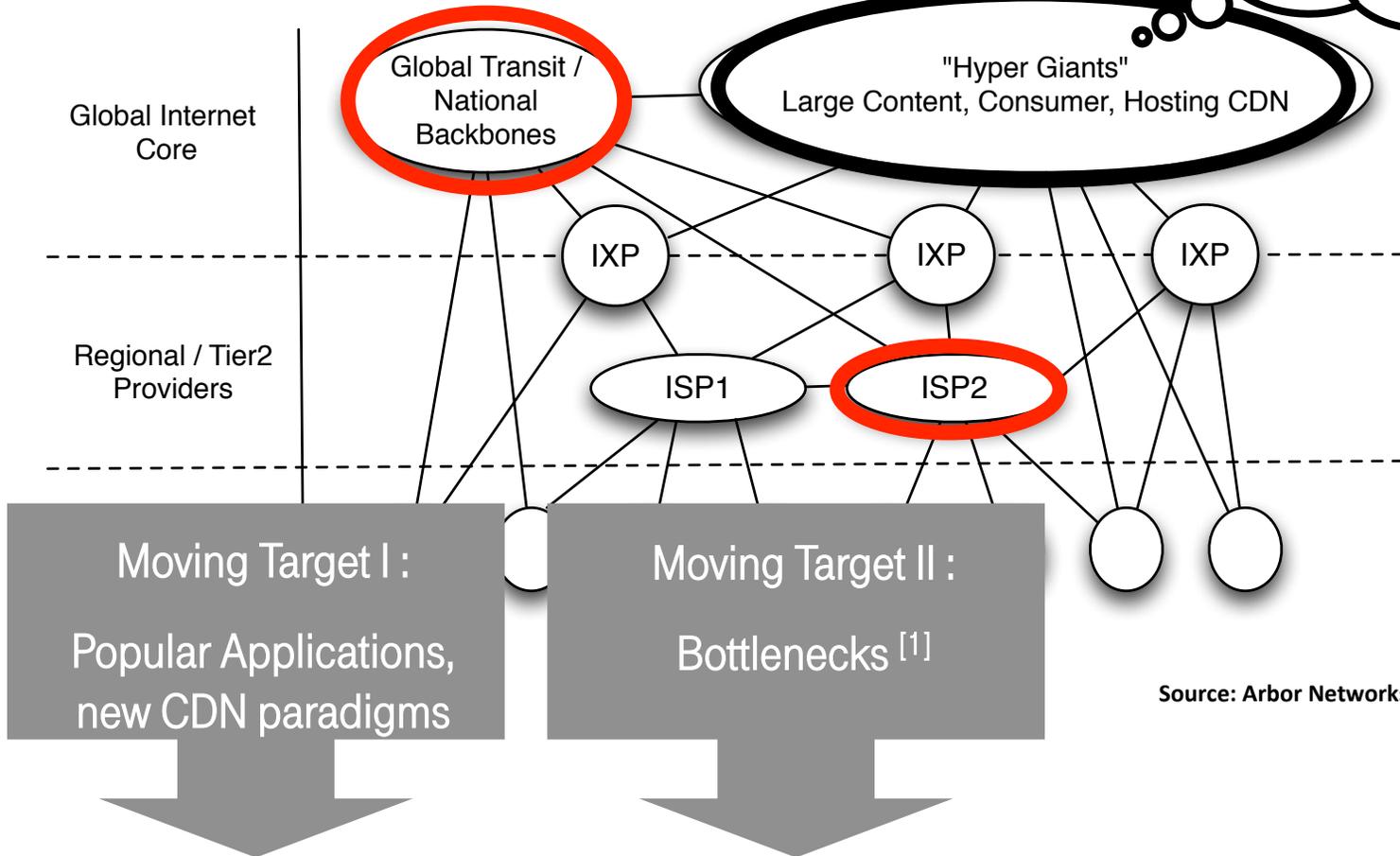
Adjust routing or peering

- Offline process
- Oscillations [1]

Source: Arbor Networks 2010

[1] "Internet Traffic Engineering by Optimizing OSPF Weights", Fortz, Thorup, INFOCOM 2000

New Challenges



Source: Arbor Networks 2010

[1] "Improving Performance on the Internet", Leighton, CACM 2009

New Challenges



Global
Regulatory
Cloud

[1] "Im

FT.com / Technology - Google accused of YouTube 'free ride' - Mozilla Firefox

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Google accused of YouTube 'free ride'

By Andrew Parker in London and Richard Waters in San Francisco
Published: April 9 2010 22:42 | Last updated: April 9 2010 22:42

Some of Europe's leading telecoms groups are squaring up for a fight with Google over what they claim is the free ride enjoyed by the technology company's YouTube video-sharing service.

Telefónica, France Telecom and Deutsche Telekom all said Google should start paying them for carrying bandwidth-hungry content such as YouTube video over their networks.

It underlines how Google's relationship with leading telecoms groups is becoming increasingly fractious, partly because YouTube video is fuelling an explosion of data traffic on their networks.

Some European telecoms groups fear Google will reduce them to "dumb pipes" because the internet search and advertising company pays the network operators little or nothing for carrying its content.

EDITOR'S CHOICE: Backlash as data traffic explodes - Apr-09, Agencies and developers welcome Apple's iPad - Apr-09, Lex: Apple v Google - Apr-09, In depth: Apple - Jul-16, In depth: Google - Mar-22, Apple to battle with Google for mobile ads - Apr-08

Telecoms groups are spending billions on infrastructure to increase broadband capacity, some fear they may struggle to pay for it.

Global mobile telecoms market
Broadband users (m)
300

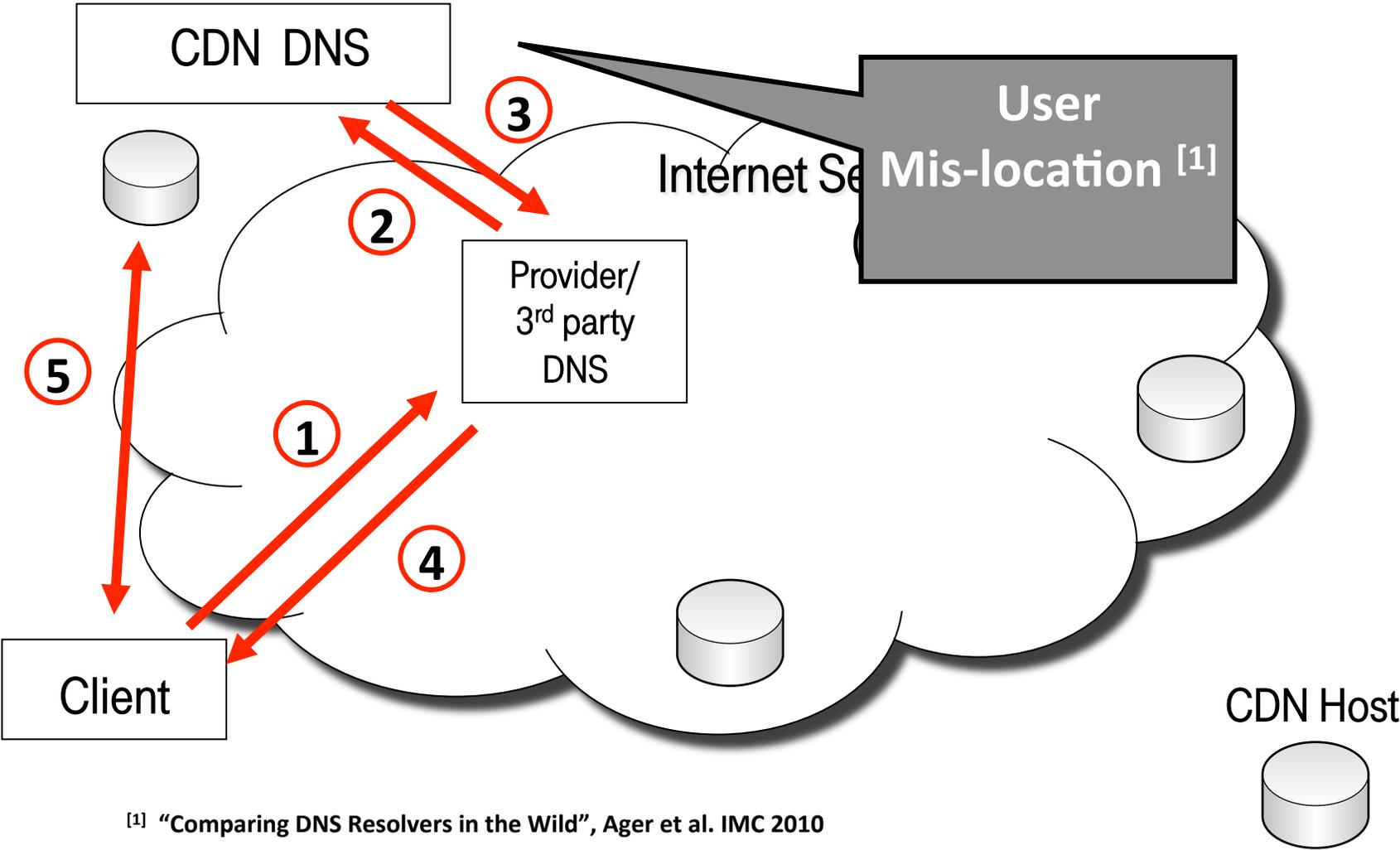
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The Financial Times Now on iPad

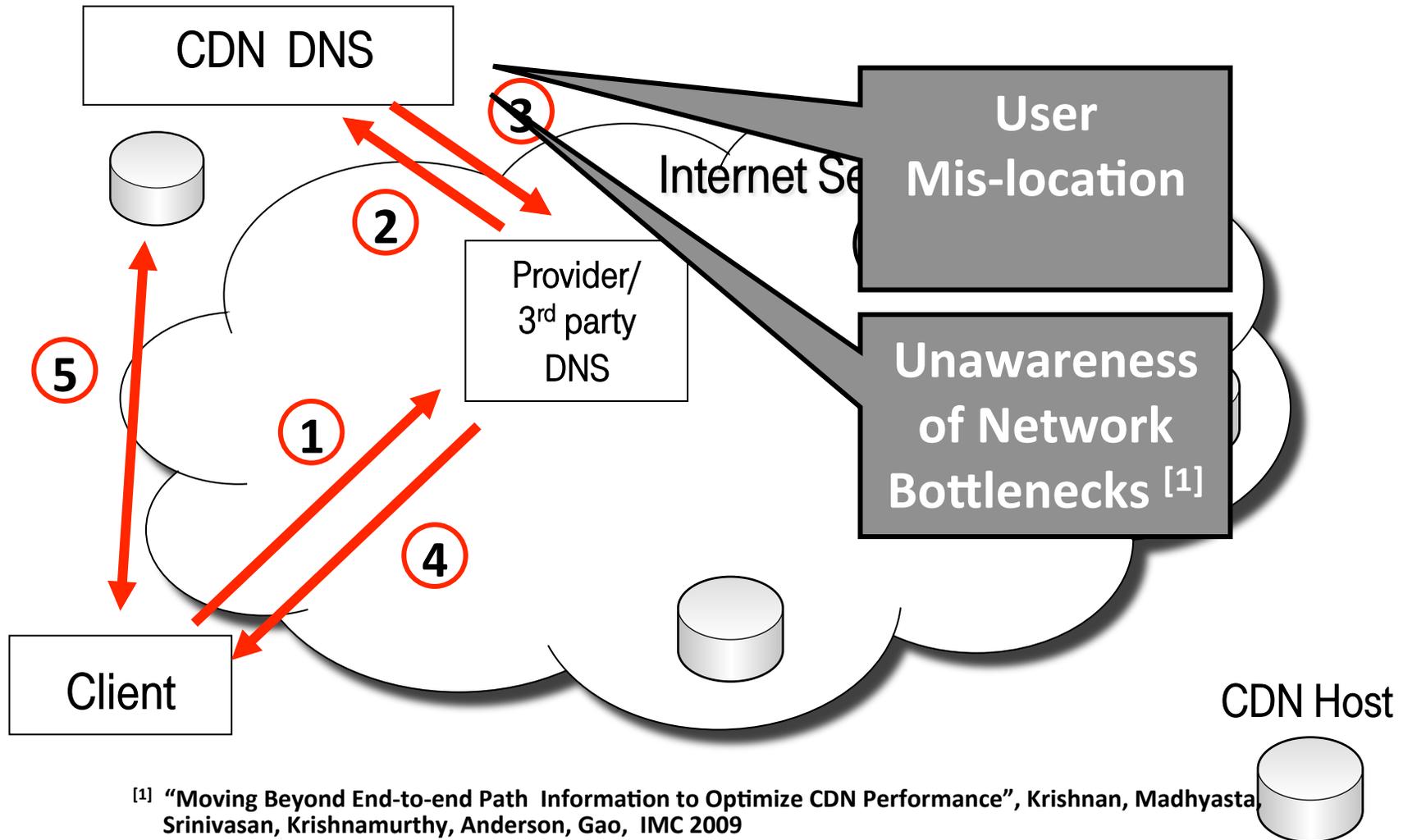
When ISPs lose the control and monetization of their network:
"René Obermann, Deutsche Telekom's chief executive, said Google and others should pay telecoms groups for carrying content on their networks"

Content Distribution Challenges

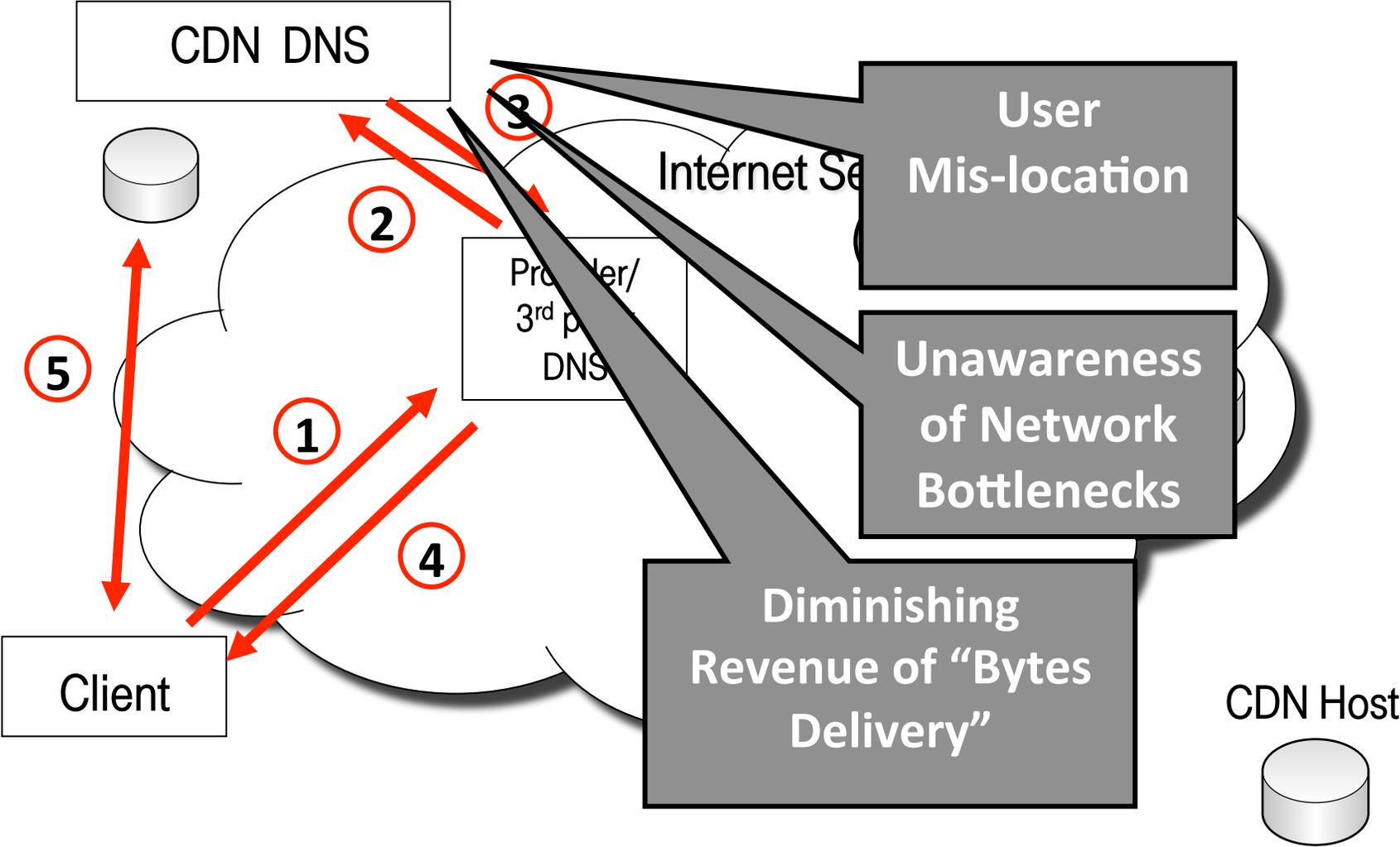


[1] "Comparing DNS Resolvers in the Wild", Ager et al. IMC 2010

Content Distribution Challenges

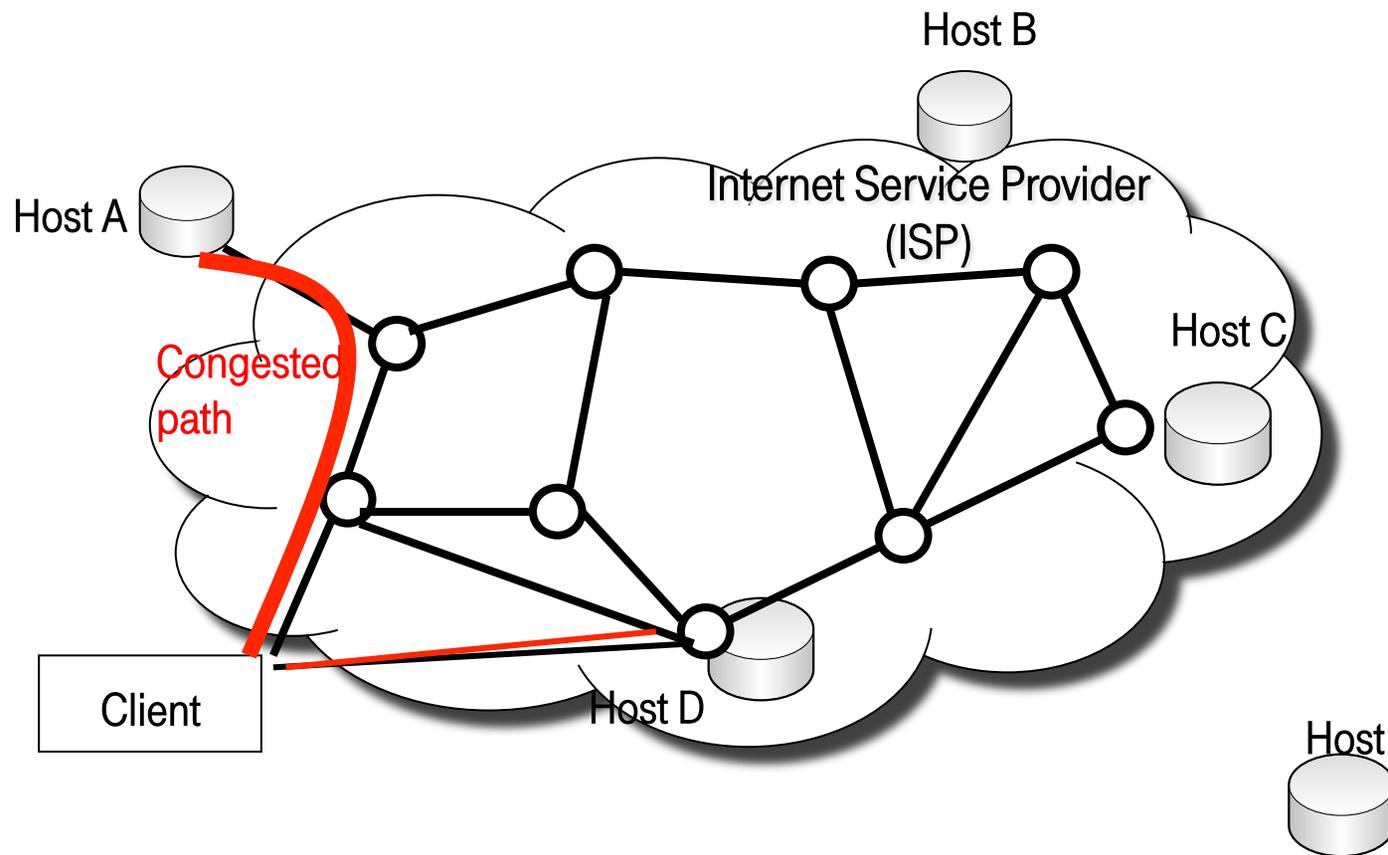


Content Distribution Challenges



Grand Challenge

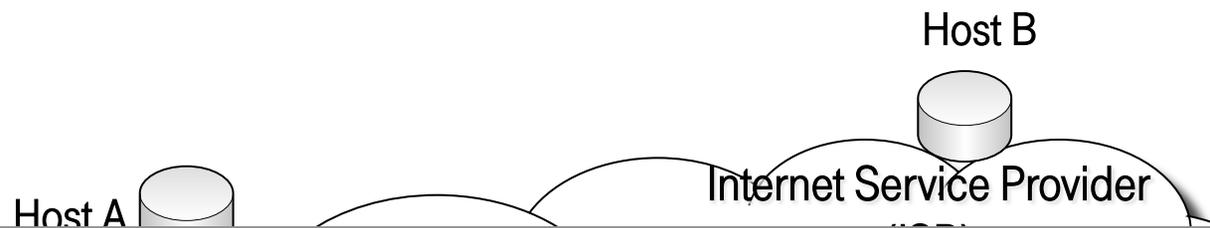
Dynamically adapts traffic demand by taking advantage of server and path diversity, and ISP network knowledge!



[1] "Content-aware Traffic Engineering", Frank et al. SIGMETRICS 2012, CCR 2012

Grand Challenge

Dynamically adapts traffic demand by taking advantage of server and path diversity, and ISP network knowledge!



Requirements:

- Online Process
- No Routing Re-configuration
- No Additional Investments/Possible OpEx Reduction
- Transparent to end-users

[1] "Content-aware Traffic Engineering", Frank et al. SIGMETRICS 2012, CCR 2012

Grand Challenge

Dynamically adapts traffic demand by taking advantage of server and path diversity, and ISP network knowledge!

win-win situation

→ A new paradigm for negotiations and collaboration!

E.g. joint products, rethinking VoD, rewards if you behave nicely.

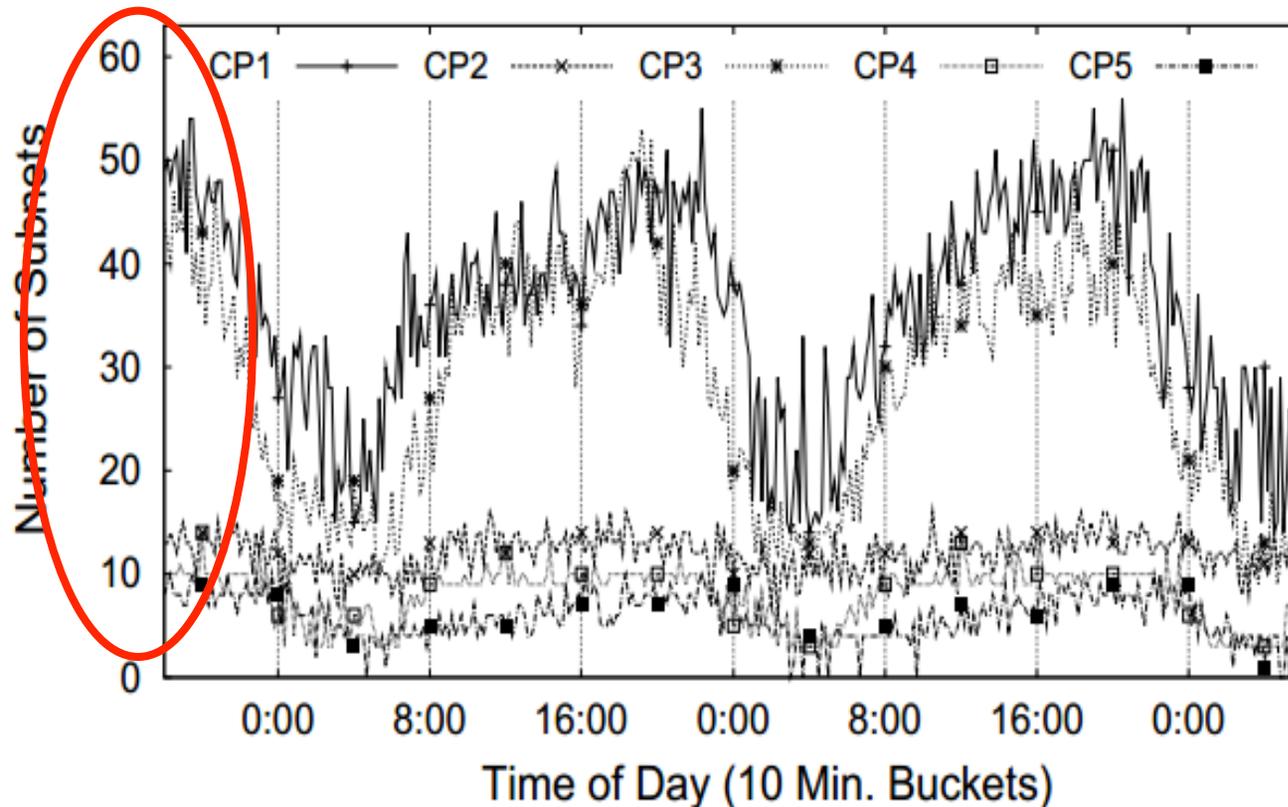
→ A new blue print to design networks!

E.g., making decisions: backbones or colocation/exchange points?

Is remote peering enough?

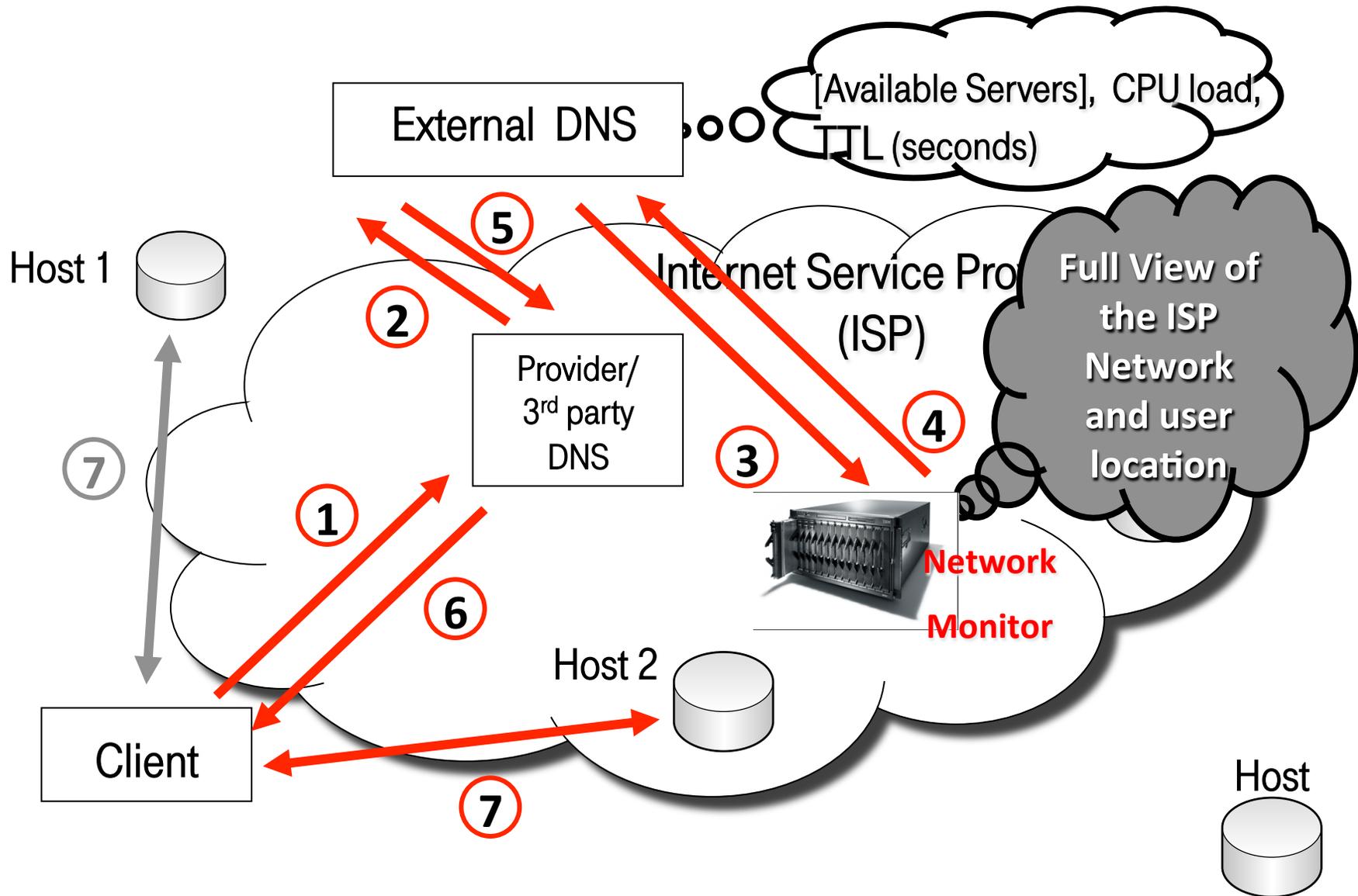
[1] "Content-aware Traffic Engineering", Frank et al. SIGMETRICS 2012, CCR 2012

Network Diversity of CDN Servers

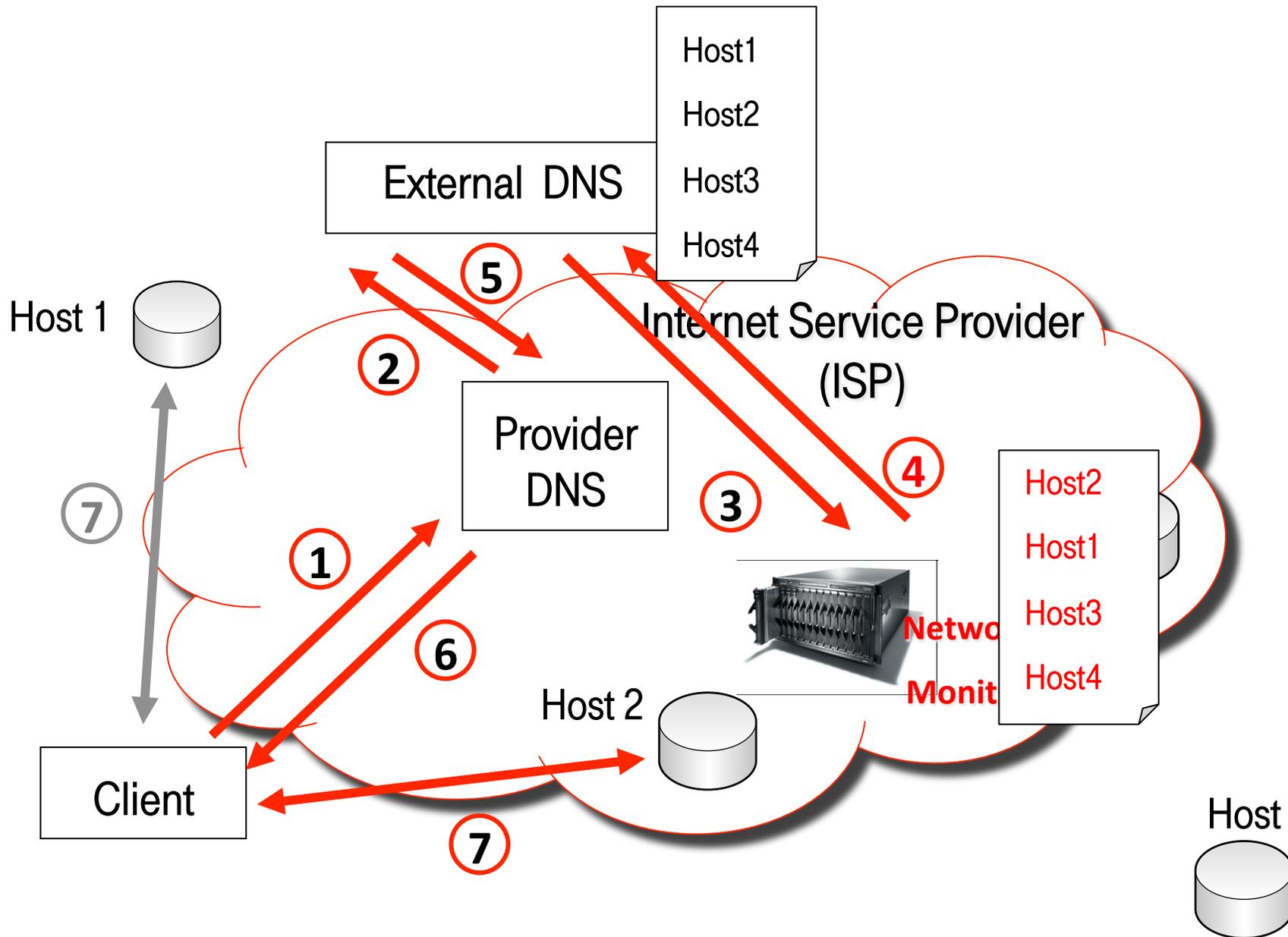


- Significant Network Diversity of servers over time for top content providers, especially during peak time
- Typically, a significant number (3 to 10) of different paths to access the content are available

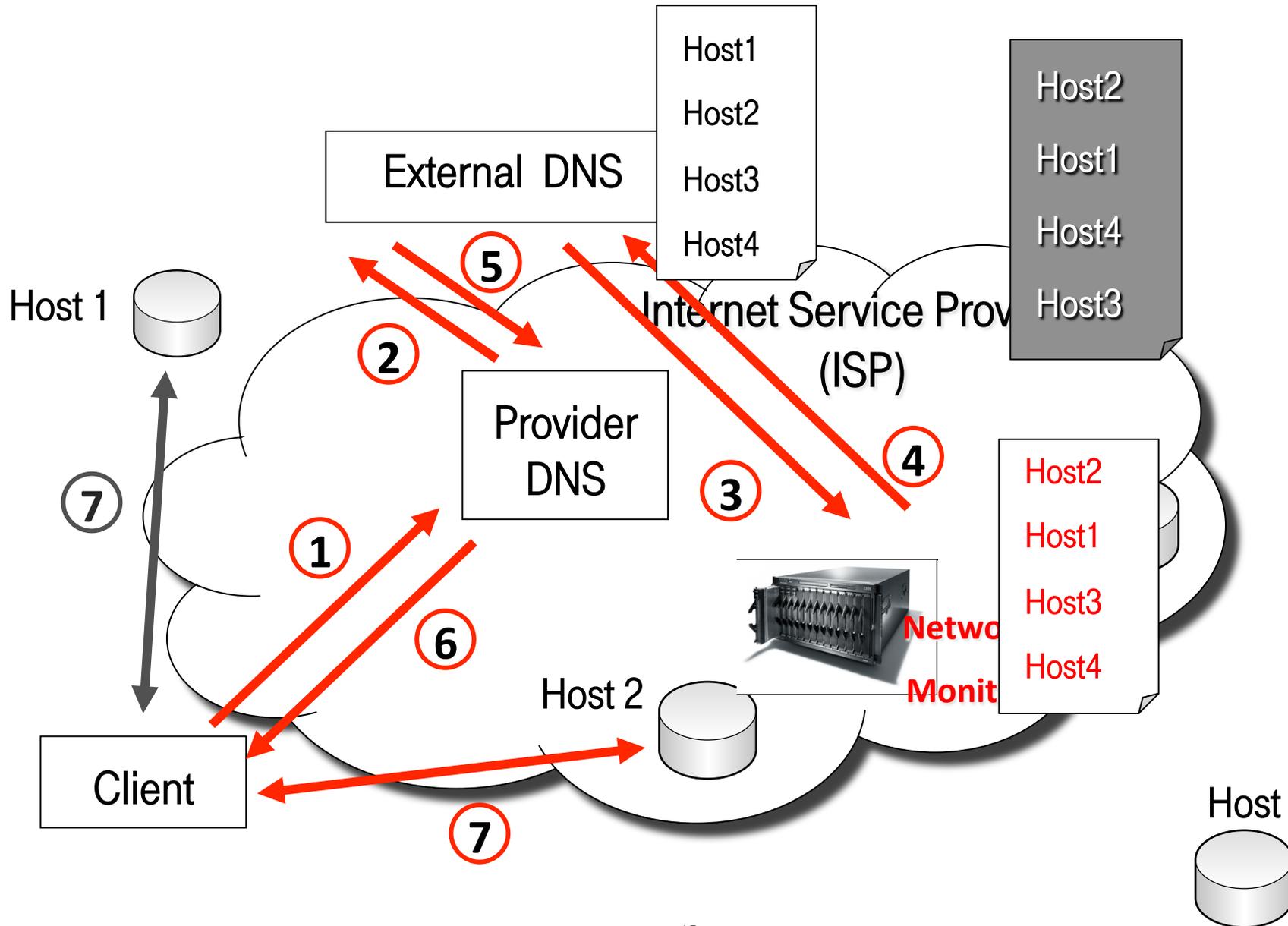
ISP-CDN Collaboration



ISP-CDN Collaboration

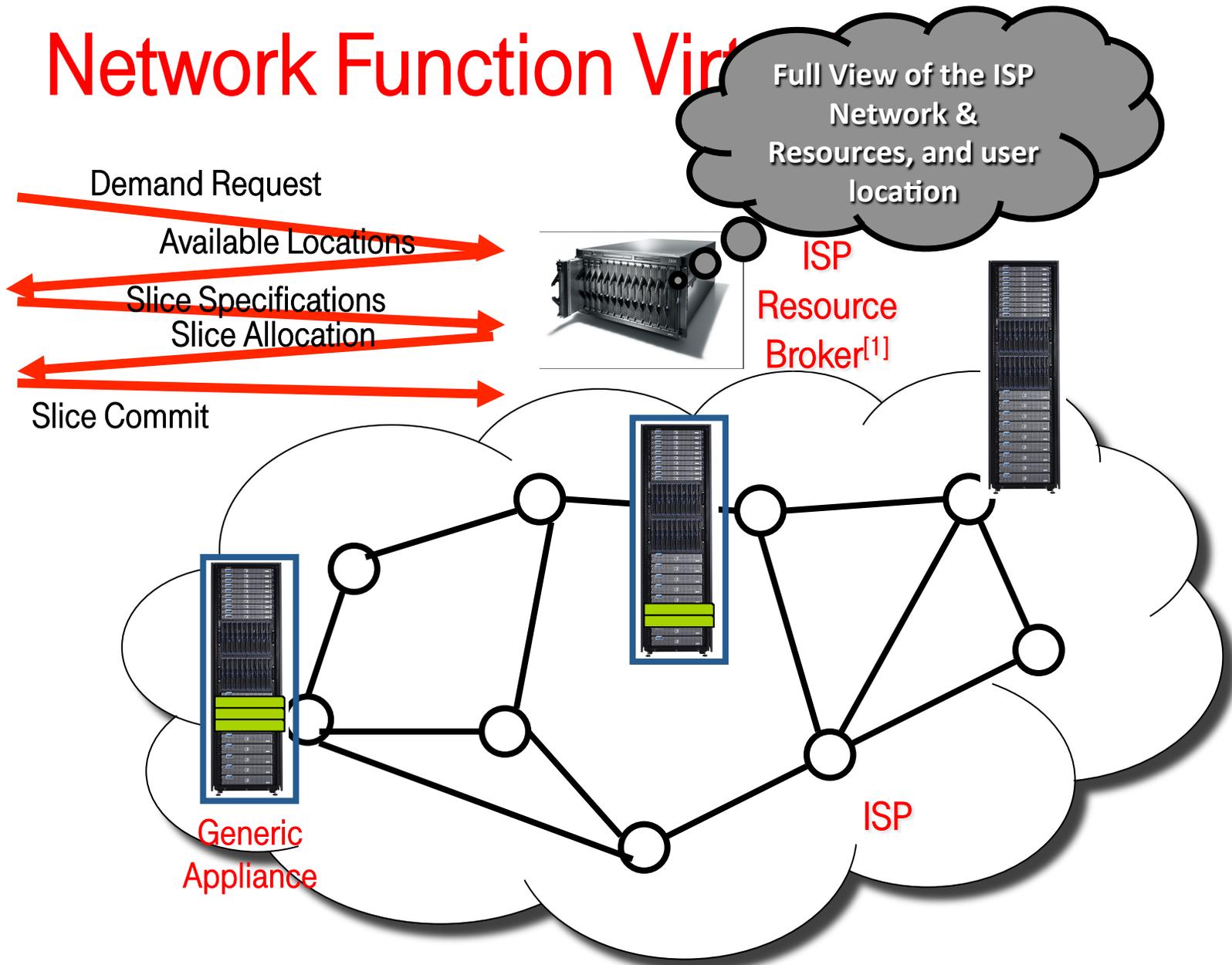


ISP-CDN Collaboration



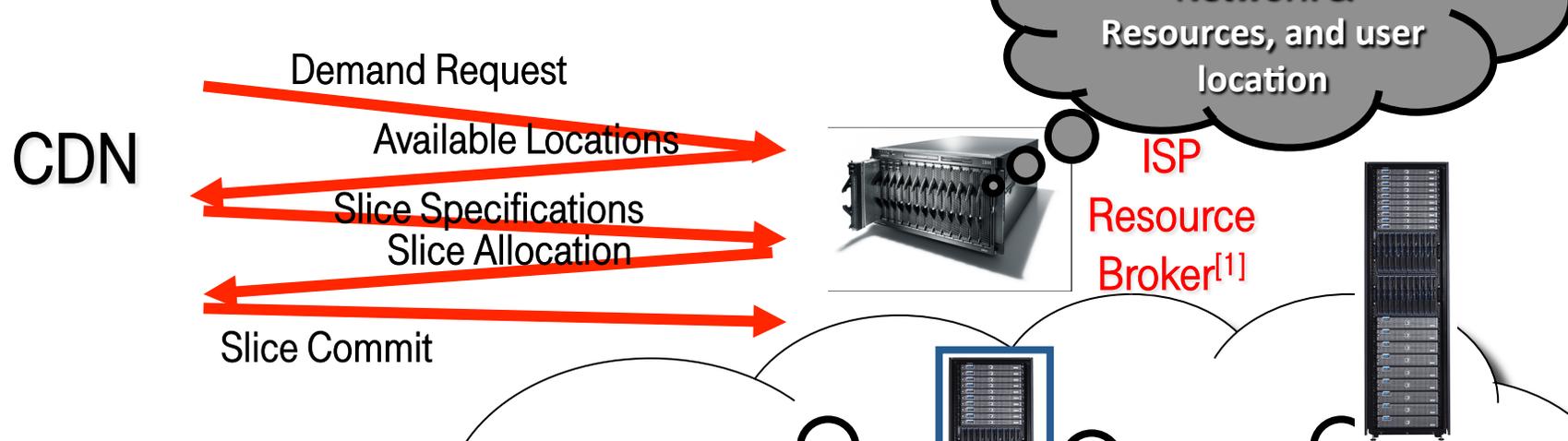
Network Function Virtualization

CDN



[1] "Pushing CDN-ISP Collaboration to the Limit", Frank et al. CCR, July 2013

Network Function Virtualization

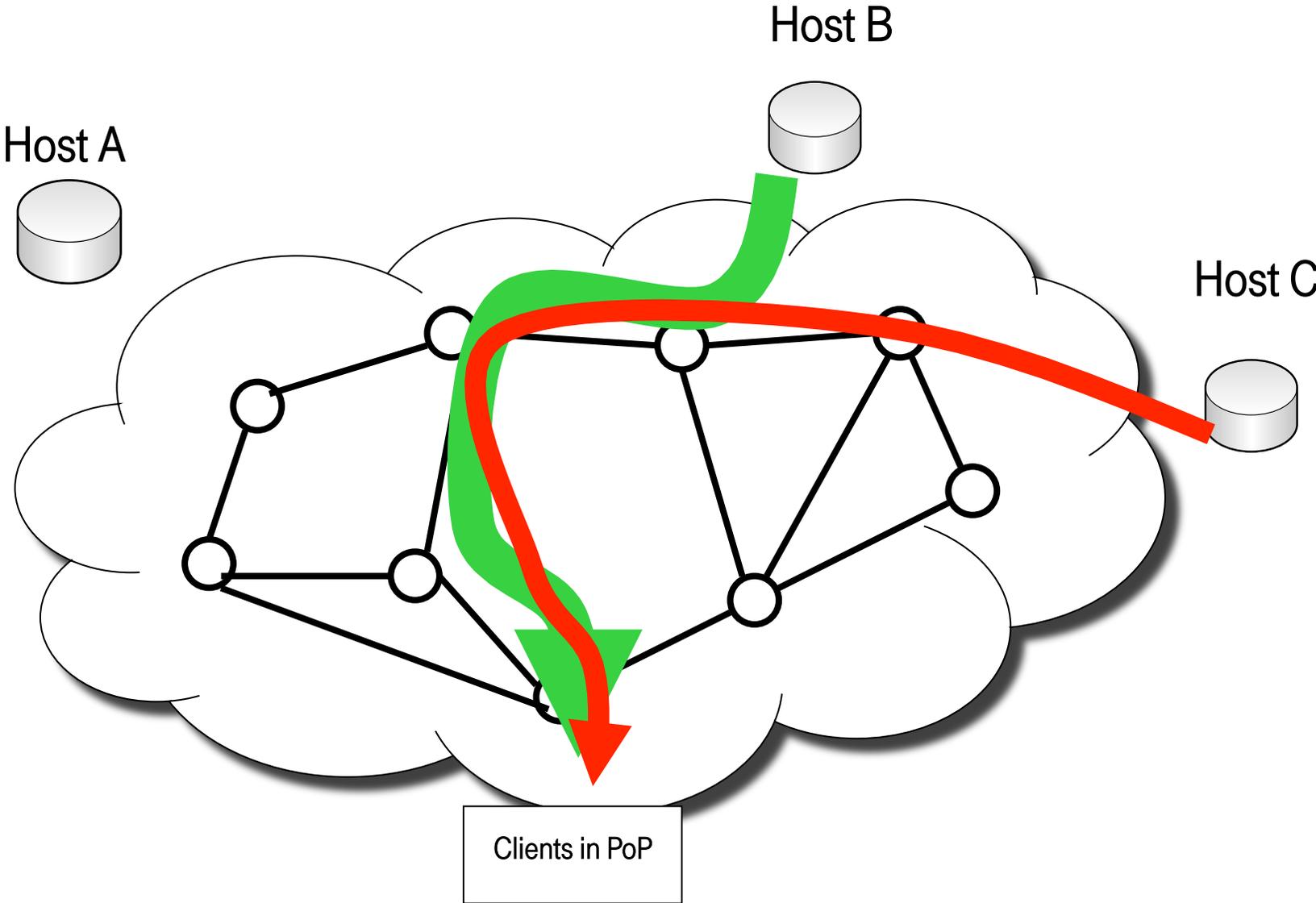


Short-time scales:
on-demand CDN deployment

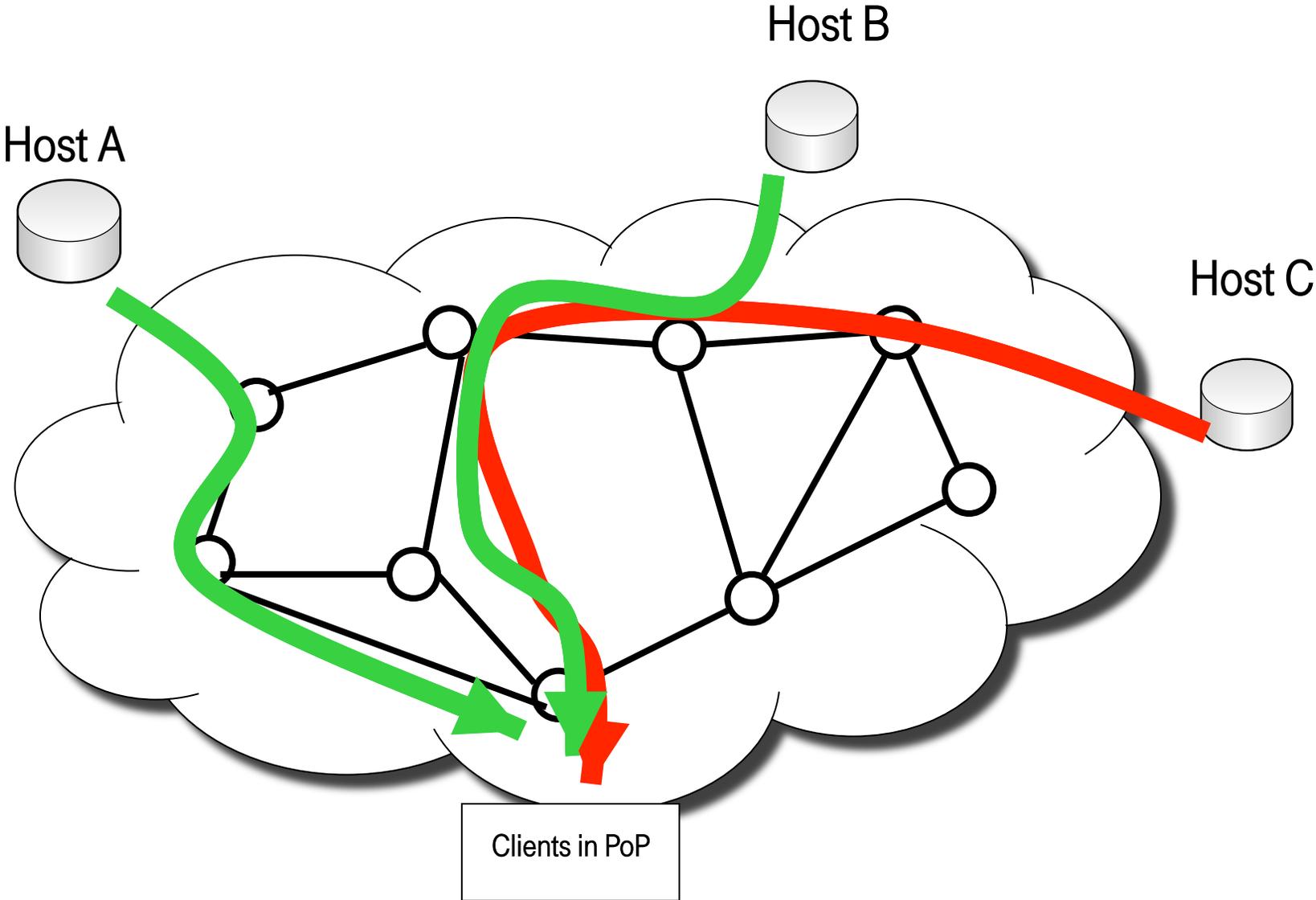
Long-time scales:
Placement of CDN servers (Gogle GGC, Netflix OpenConnect,..), Licensed CDN (Akamai, Edgecast,..)

[1] "Pushing CDN-ISP Collaboration to the Limit", Frank et al. CCR, July 2013

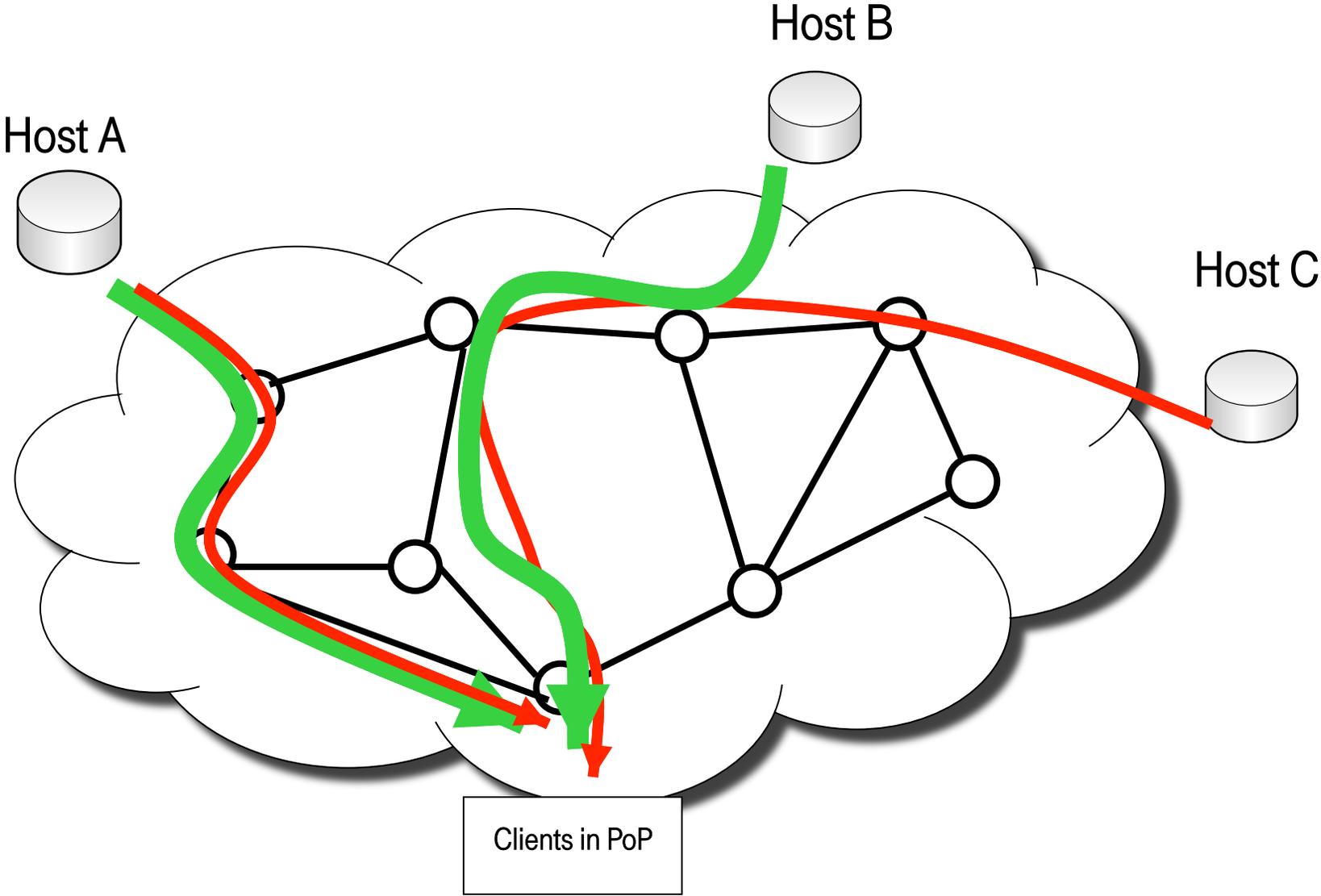
Network Load Balancing



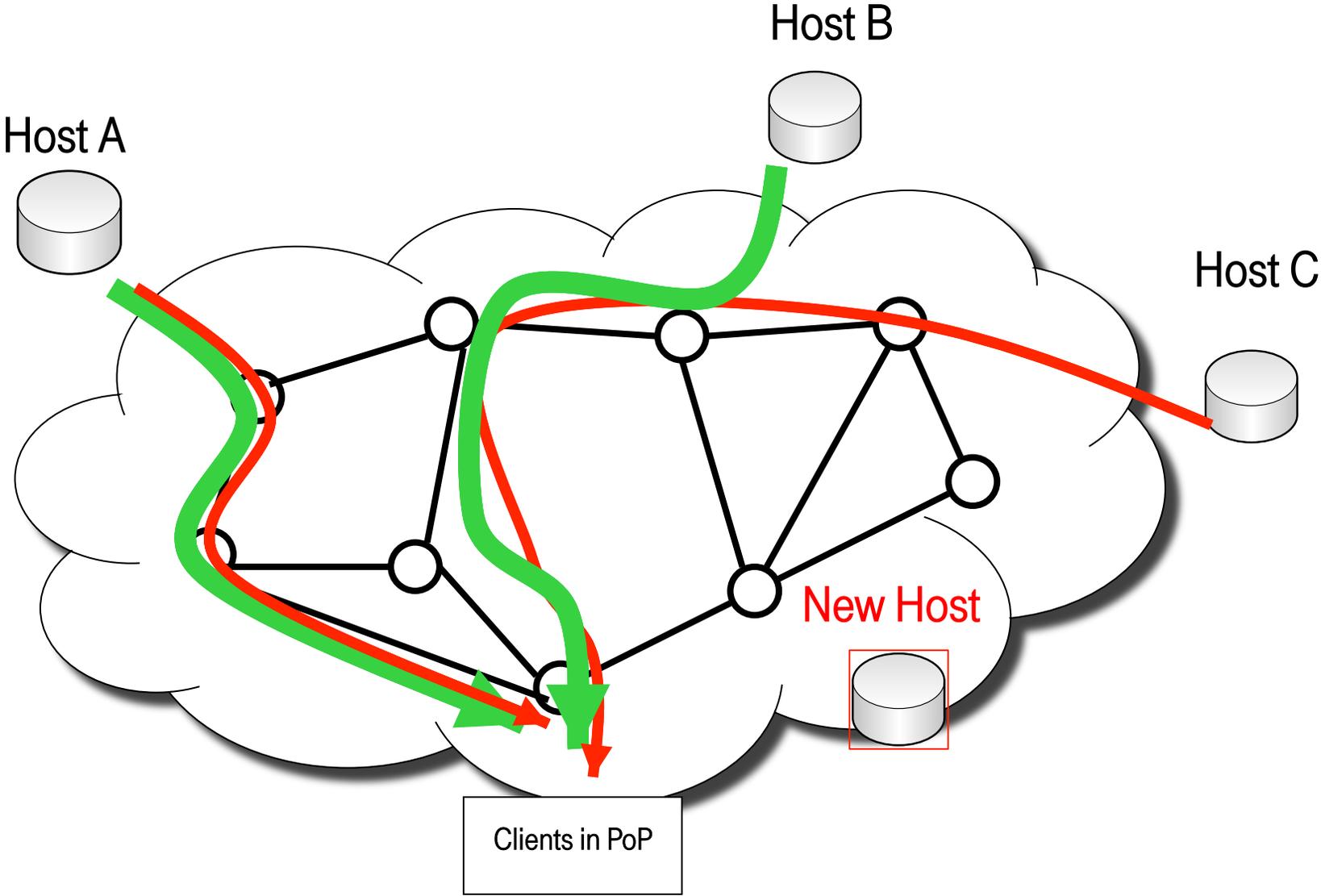
Network Load Balancing



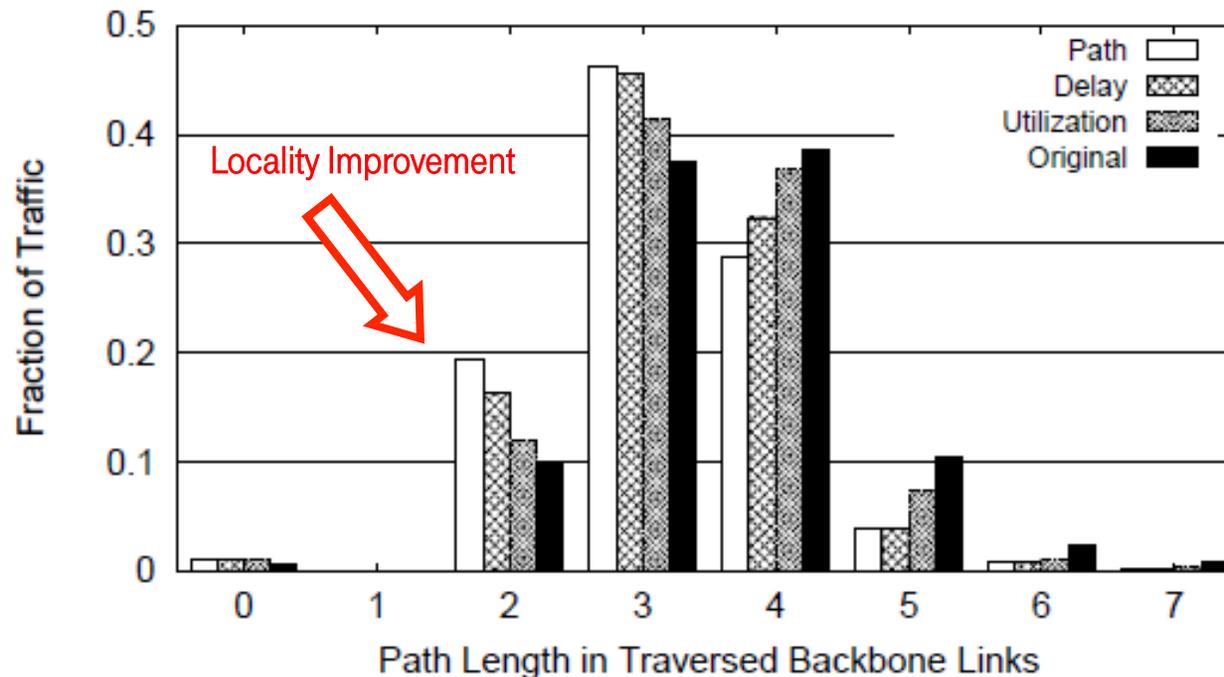
Network Load Balancing



Network Load Balancing



An Opportunity for Better Traffic Engineering



- Moving traffic from congested link to less congested
- Improvement in the networks capacity (10-20%)
- Performance improvements in multiple metrics

Summary

- A large fraction of the Internet traffic is due to a small number of CDNs
- Opportunity for joint CDN deployment and co-operation by ISP and CDN by utilizing:
 - (1) server and path diversity
 - (2) knowledge about the network and user location
 - (3) flexible server deployment
- Benefits for all involved parties including CDNs, ISPs, end-users

Thank you!

<http://www.smaragdakis.net/research/Collaboration>