

Assessing Access Network Market Power

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Access Network Market Power

- Limited access network competition has the potential to impact:
 - Consumer pricing
 - Likelihood of harmful discrimination against traffic or users
 - Interconnection agreements?
- *Does concentration in access networks impact the ability of other network providers to deliver traffic to those end users?*
- *How can access network market power be assessed?*

Market Share and Market Power Metrics

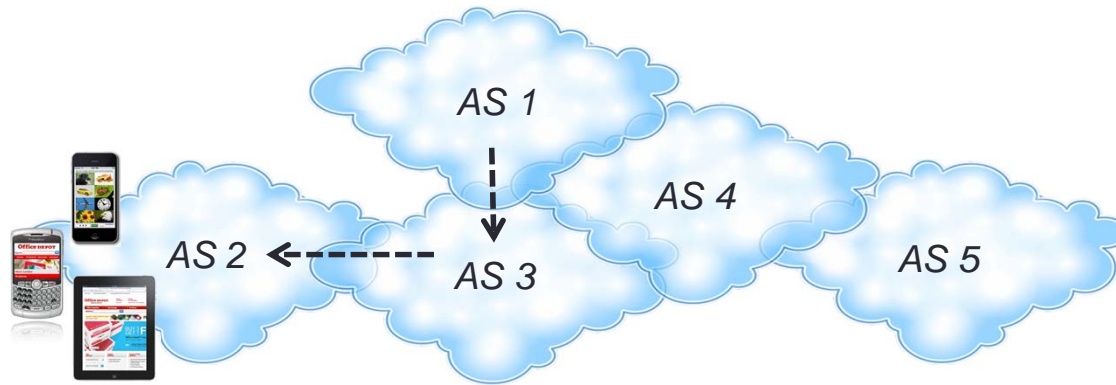
- D'Ignazio and Giovannetti have proposed two metrics:
 - *Customer cone (CAIDA)*: associates rank to each AS by looking at their location in the Internet hierarchy
 - *Betweenness (centrality)*: betweenness for an AS is given by the number of BGP paths between two other ASes that traverse that AS

$$B_s(v) = \sum_{s \neq v \neq t \in V} \sigma_{st}(v)$$

$\sigma_{st}(v) = \sigma_{ts}(v)$ Is number of shortest paths from AS s to AS t on which AS v lies on

See D'Ignazio, A. and Giovannetti, E., "Antitrust Analysis for the Internet Upstream Market: a BGP Approach," Cambridge Working Papers in Economics, 0554, 2005, and "Unfair' Discrimination in two-sided Peering? Evidence from LINX," Cambridge Working Papers in Economics, 0621, 2006.

Betweenness and Access Networks



Path	Networks in Shortest Path
1-2	3
1-3	-
1-4	-
1-5	3, 4
2-3	-
2-4	3
2-5	3, 4
3-4	-
3-5	4
4-5	-

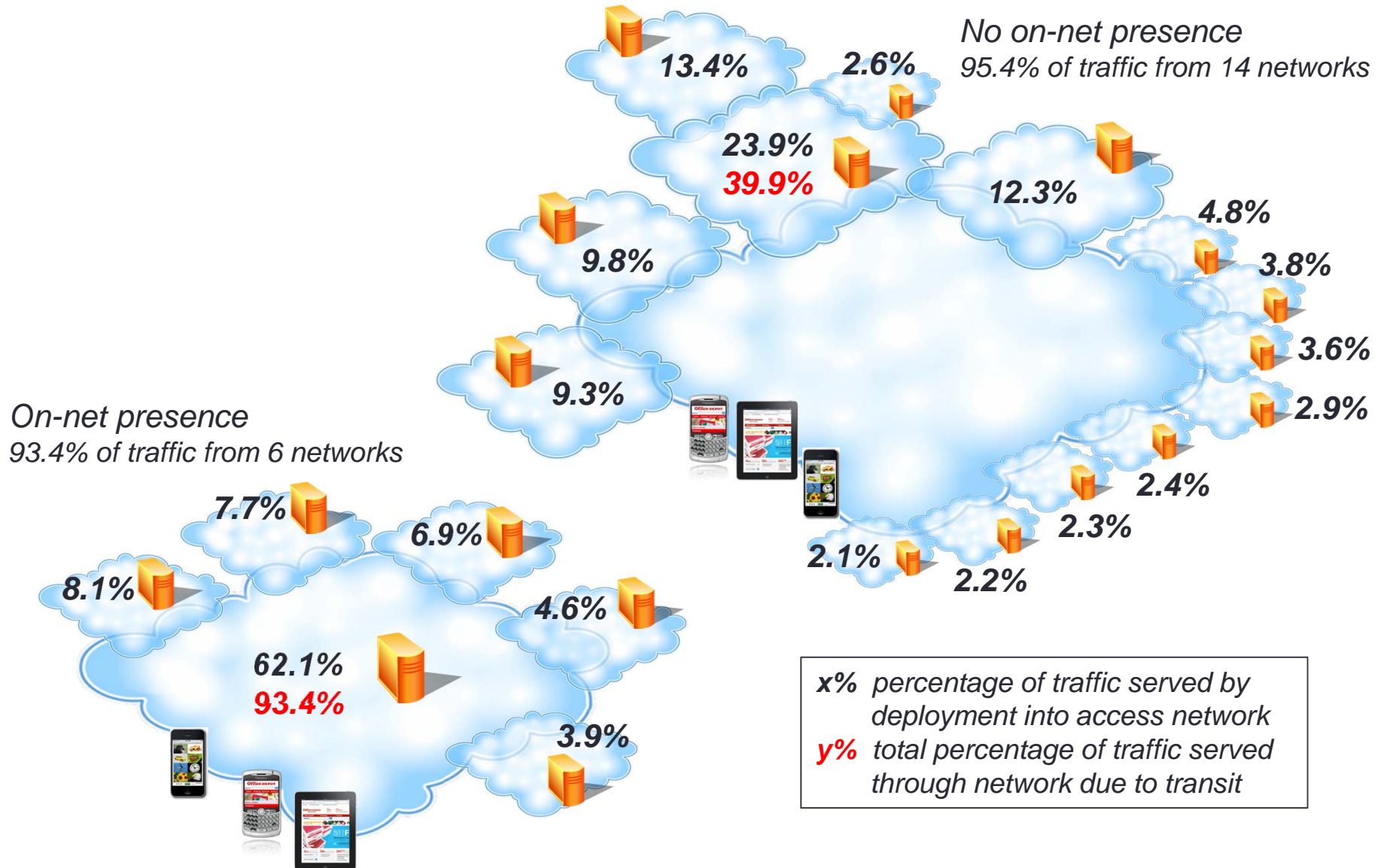
- Access network will never lie on the shortest path *between* two networks, but will always be on the shortest path if end users are an end point

Access Variance

- Variance in how content is delivered to access network's end users
 - Ability of networks and overlays to establish alternative interconnection agreements allowing for delivery to access network's end users
- Potential measurements vary with networks vs. overlays
 - Number of upstream interconnection agreements
 - Distribution of requests across CDN deployments
- One key challenge is quantifying viability of paths

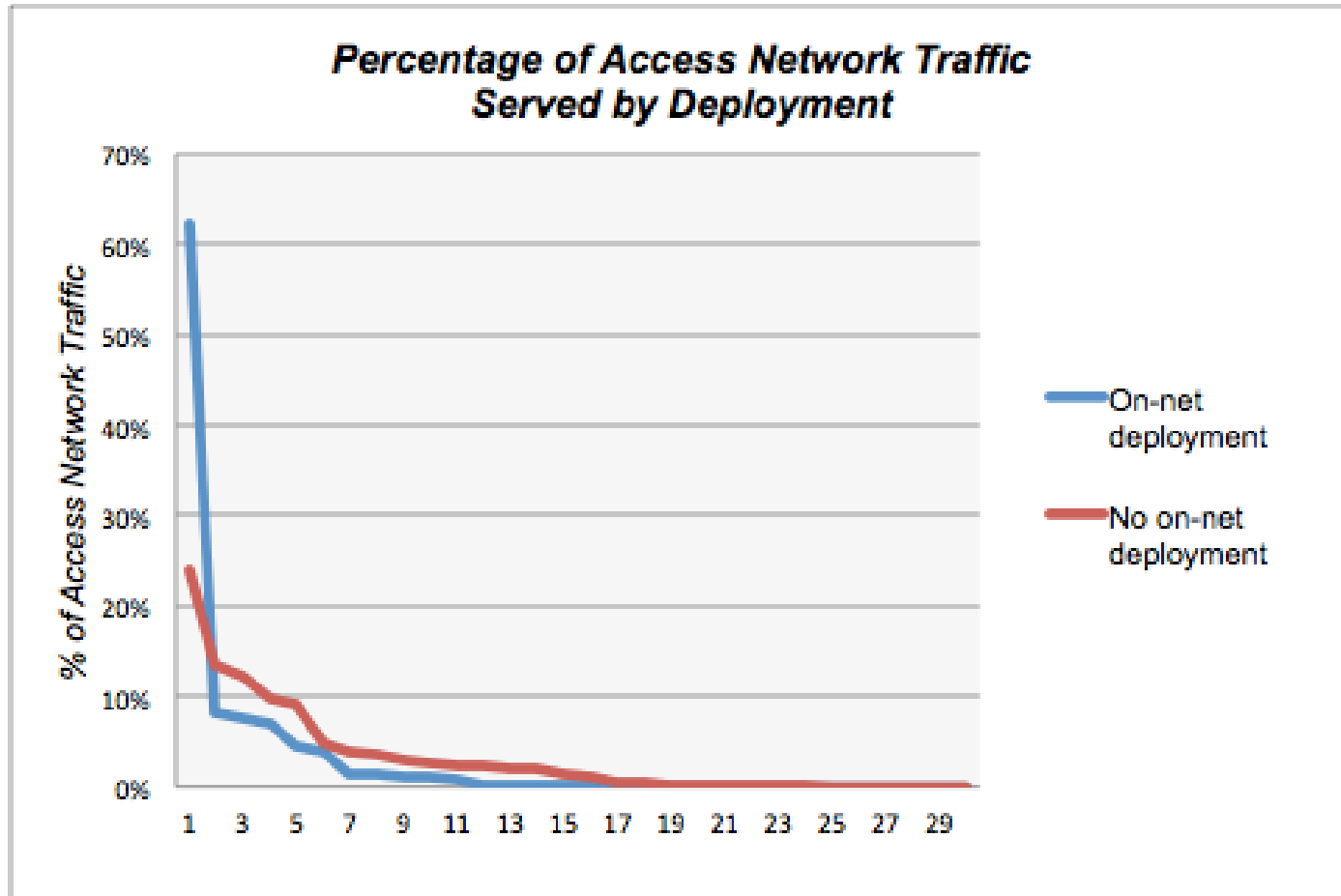


Delivery Distribution Example



Note: Drawings show deployments which serve >2% of overall traffic into access networks

Delivery Distribution Example Continued



Assessing Viability of Alternative Paths

<i>Characteristic</i>	<i>Description</i>	<i>Potential Source</i>
Network type (3G, 4G, broadband)	Help establish baseline expectations for congestion and performance	Network provider
Provisioned capacity by link	Determine total available capacity at various interconnection points	Network provider
Traffic volume	Indicate utilization of available capacity	MRTG
Packet loss	Level of acceptable packet loss will differ depending on traffic type	Pingroute, Traceping, client-side QoS monitor
Traffic profile	Breakdown of traffic by content category (video, ecommerce, etc)	Deep Packet Inspection