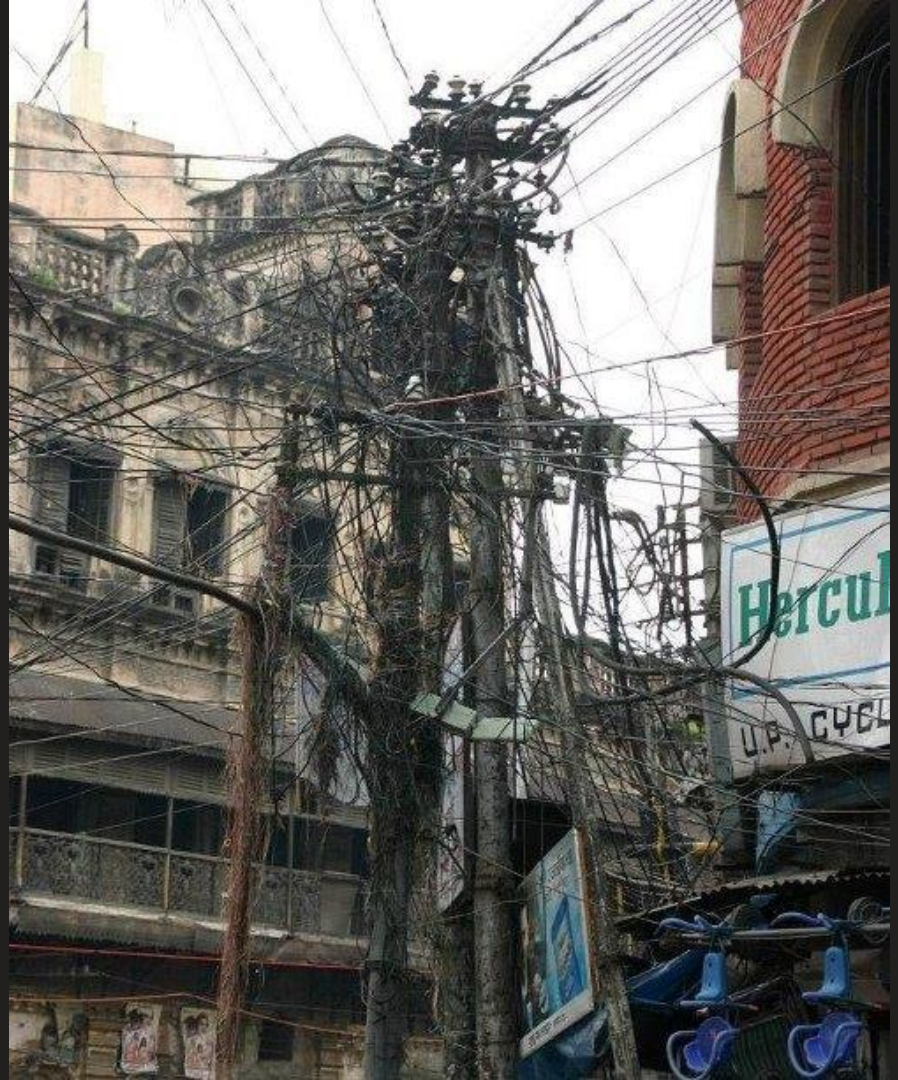
Content-Delivery Networks:

Powering Network Infrastructure for the Future

Michael K. Smith
Director of APAC Interconnection
Netflix

Network and Internet Engineering
Datacenter Deployment
CDN Engineering
Community Outreach
(NANOG, APRICOT)
Internet Security

What’s the prevailing “wisdom” about Internet in India?


Hercul
U.P. CYCL

The common theme is “extremes” and all the terms are emotionally charged

So what is network performance really like in India?

- Per-subscriber throughput
- TCP Retransmits
- Network congestion at the provider level
- Median Play Delay

How does Netflix measure Quality of Experience?

India and Brazil

Compare and Contrast

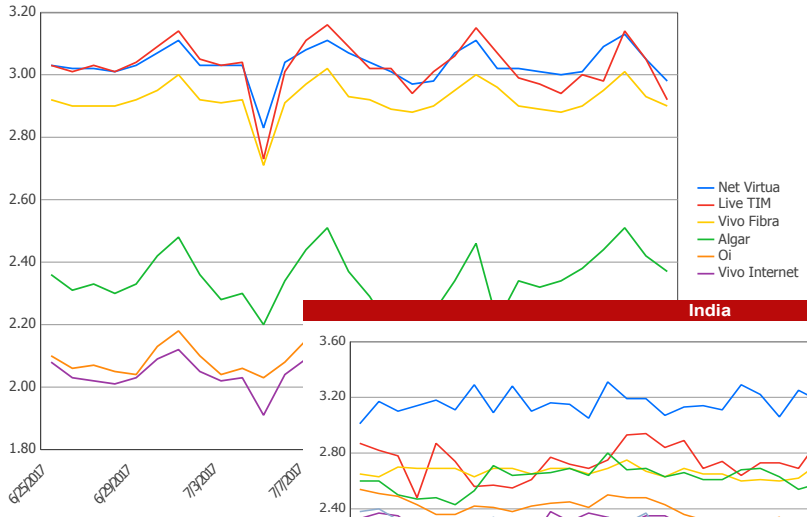
Country Statistics Comparison

	Broadband Households	4G Mobile
India	18.8 Million	124 Million
Brazil	27.2 Million	70 Million

Source: http://www.telegeography.com

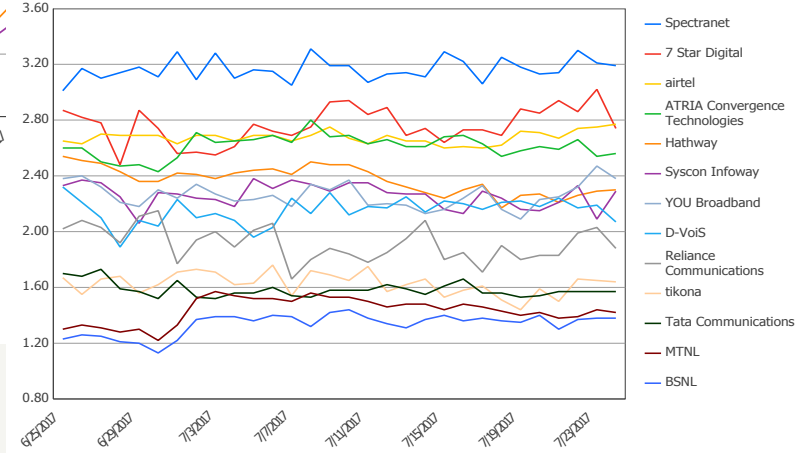
ISP Speed Index

Brazil

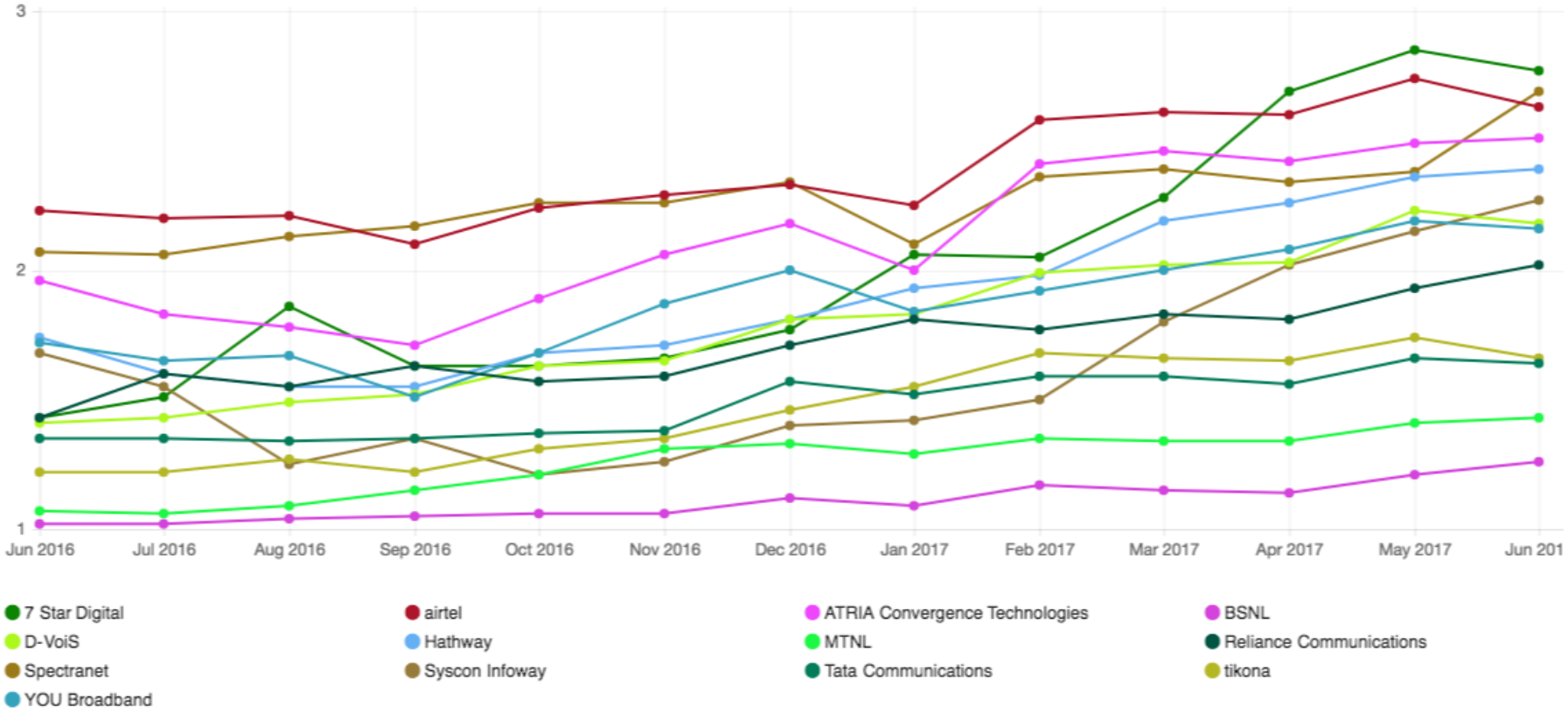


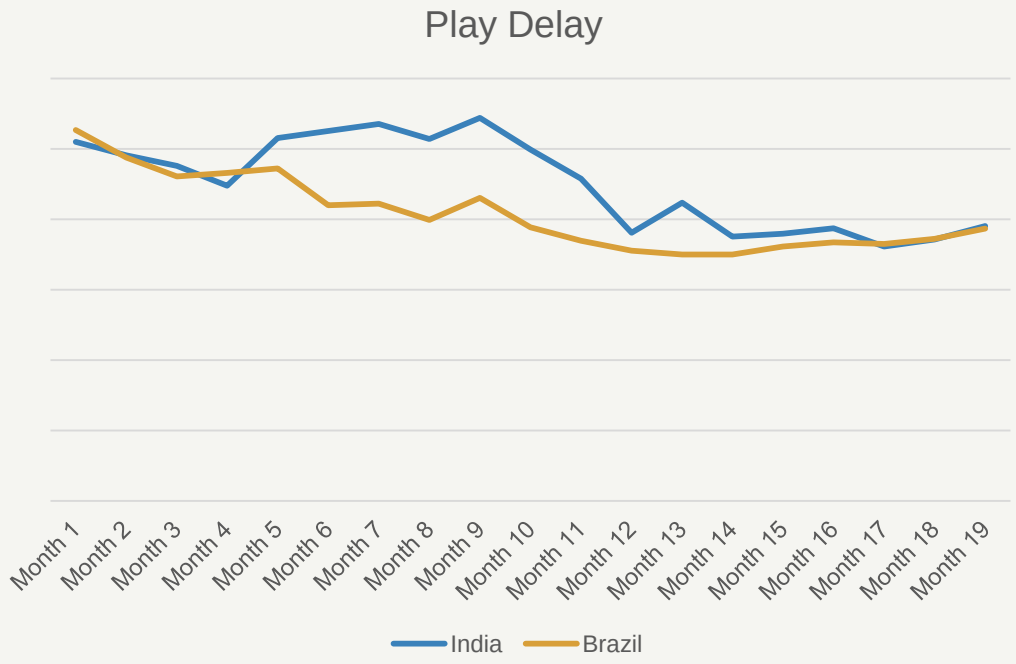
ISP	Speed (Mb)	Rank
Net Virtua	3.04	1
Live TIM	3.03	2
Vivo Fibra	2.92	3
Algar	2.35	4
Oi	2.08	5
Vivo Internet	2.05	6

India



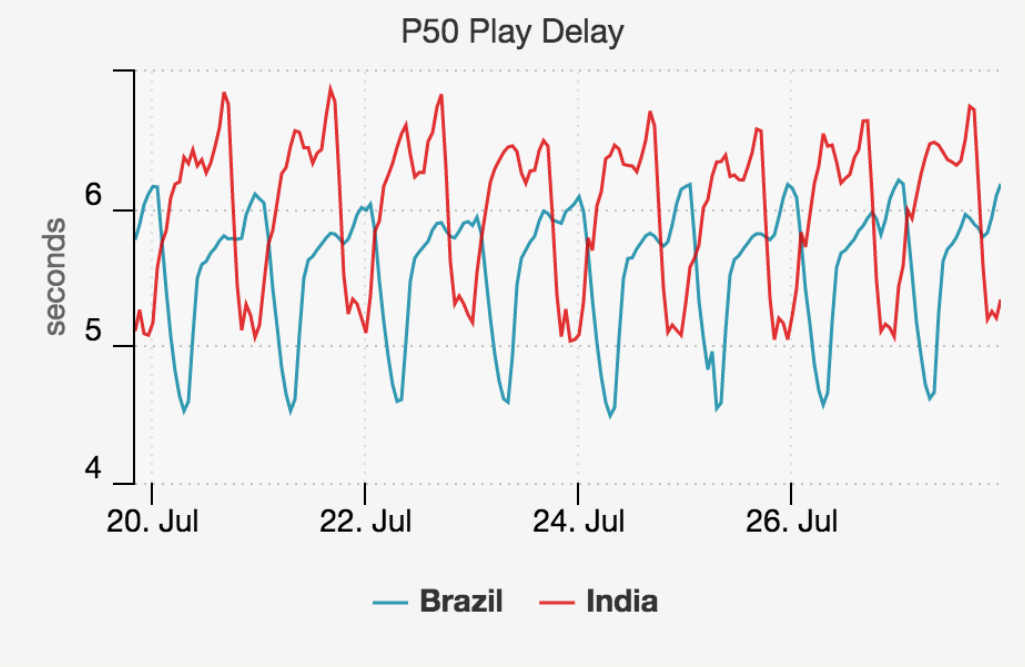
ISP	Speed (Mb)	Rank
Spectranet	3.17	1
7 Star Digital	2.77	2
airtel	2.68	3
ATRIA Convergence Technologies	2.62	4
Hathway	2.37	5
YOU Broadband	2.26	6
Syscon Infoway	2.26	7
D-VoiS	2.15	8
Reliance Communications	1.92	9
tikona	1.63	10
Tata Communications	1.58	11
MTNL	1.44	12
BSNL	1.34	13


3
2
1
Jun 2016
Jul 2016
Aug 2016
Sep 2016
Oct 2016
Nov 2016
Dec 2016
Jan 2017
Feb 2017
Mar 2017
Apr 2017
May 2017
Jun 201
7 Star Digital
airtel
ATRIA Convergence Technologies
BSNL
D-VoiS
Hathway
MTNL
Reliance Communications
Spectranet
Syscon Infoway
Tata Communications
tikona
YOU Broadband



Play Delay

- India and Brazil
- First 19 Months



Play Delay

- India and Brazil
- Today

We expect India to grow like Brazil

Consistent growth in content viewing

Robust competitive OTT environment

Increasing interconnection options

Network performance is getting better

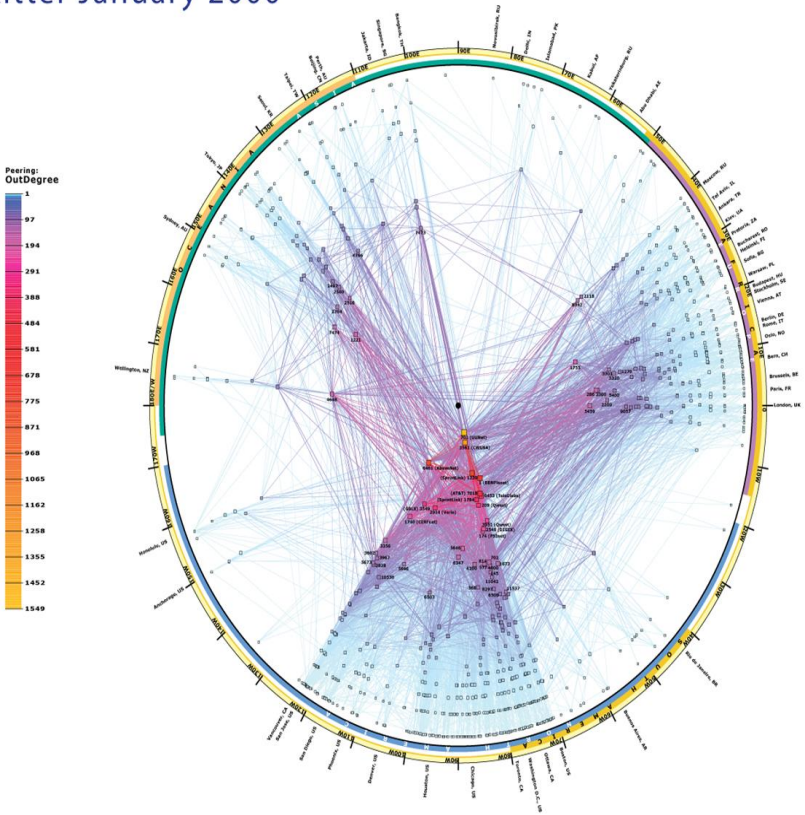
What is a CDN?

A scalable platform for increasing consumer quality of experience by maximizing the network efficiencies of moving content closer to the user.

Why are CDNs Important?

CAIDA's IPv4 AS Core
AS-level INTERNET GRAPH

Skitter January 2000



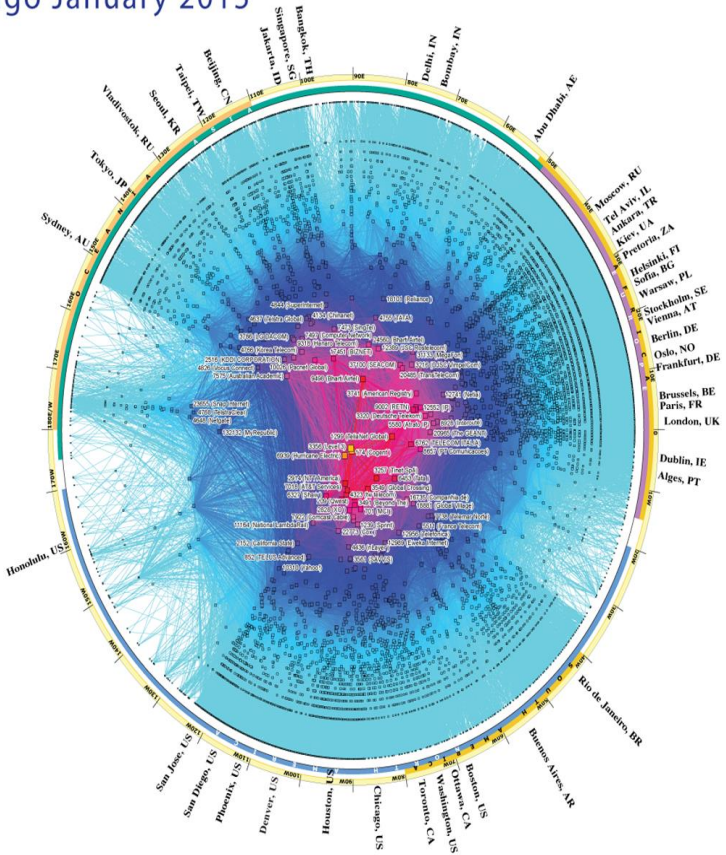
The Internet
in 2000

The Internet in 2000

- Eyeball networks
- Transit ISPs serving lots of local ISPs
- Very limited peering
- Clear-cut distinction between services
  - Transit did transit
  - Eyeballs did eyeballs
  - Content did content

CAIDA's IPv4 AS Core
AS-level INTERNET GRAPH

Archipelago January 2015



The Internet in 2015

The Internet in 2015 (Today)

- Lots of peering options
- Very few ISP options
- Network providers have multiple interests
  - Transit services
  - Access to eyeballs
  - Content

Massive growth + new ideas =
CDNs are born

1998 - Akamai
2001 - Limelight
2001+ - Edgecast (Verizon), BitGravity (Tata), Level3, Cloudflare, Fastly, etc.

Early CDN Evolution

Netflix

Google

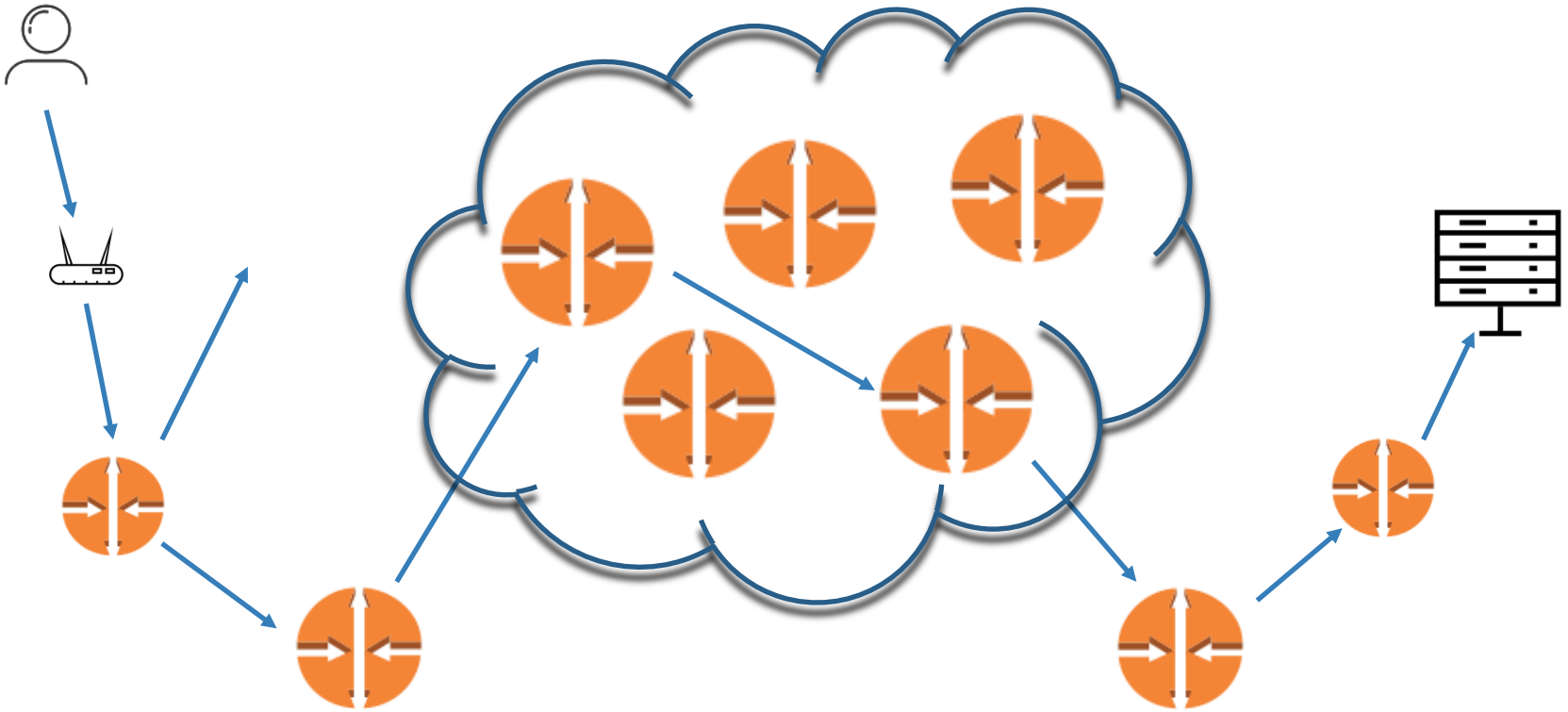
Microsoft

Achieving efficiencies at scale - single tenant CDN

How do CDNs work?

Without CDNs…

A user requests a piece of content



What CDNs Provide?

CDNs provide

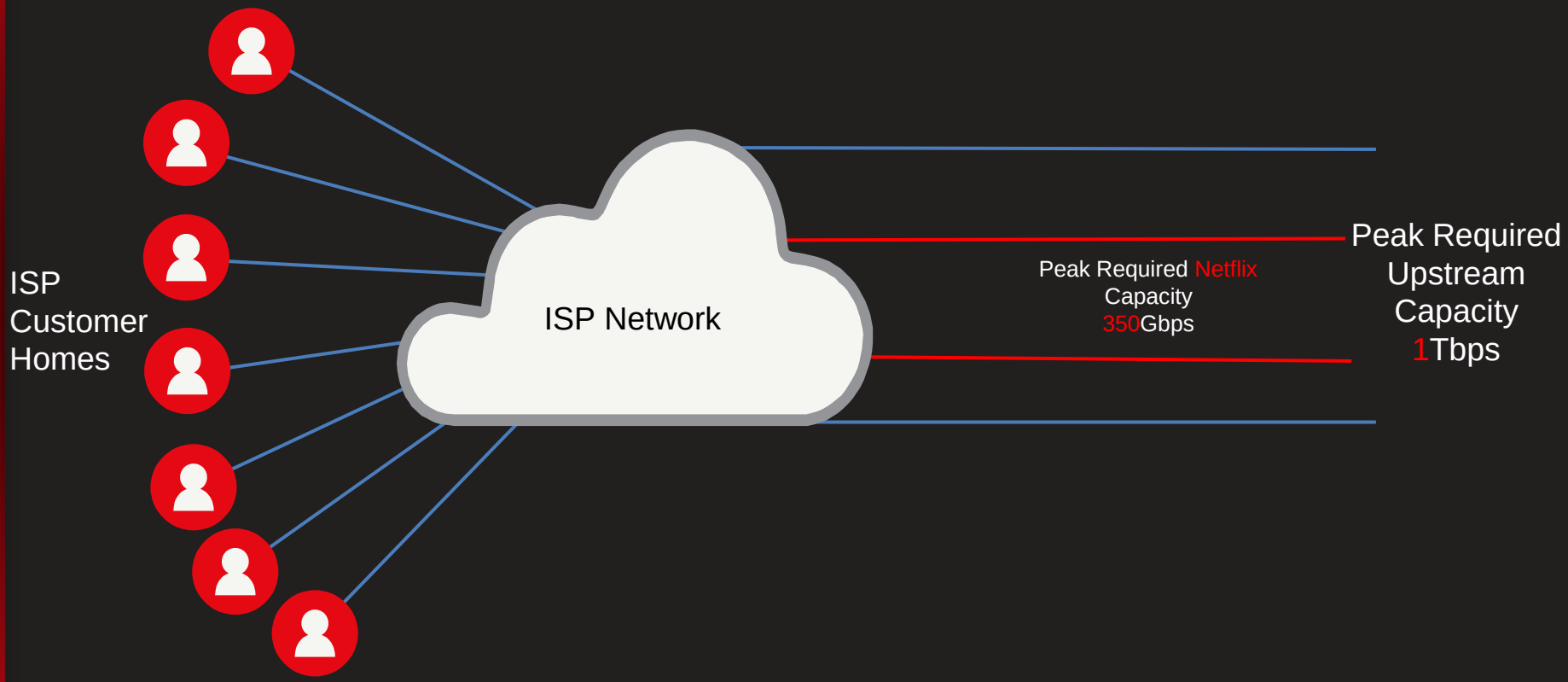
- Network efficiency through path minimization
- Quality of Experience by reducing latency and loss
- Cost efficiency by eliminating costly inter-provider links
- Internet stability through traffic localization

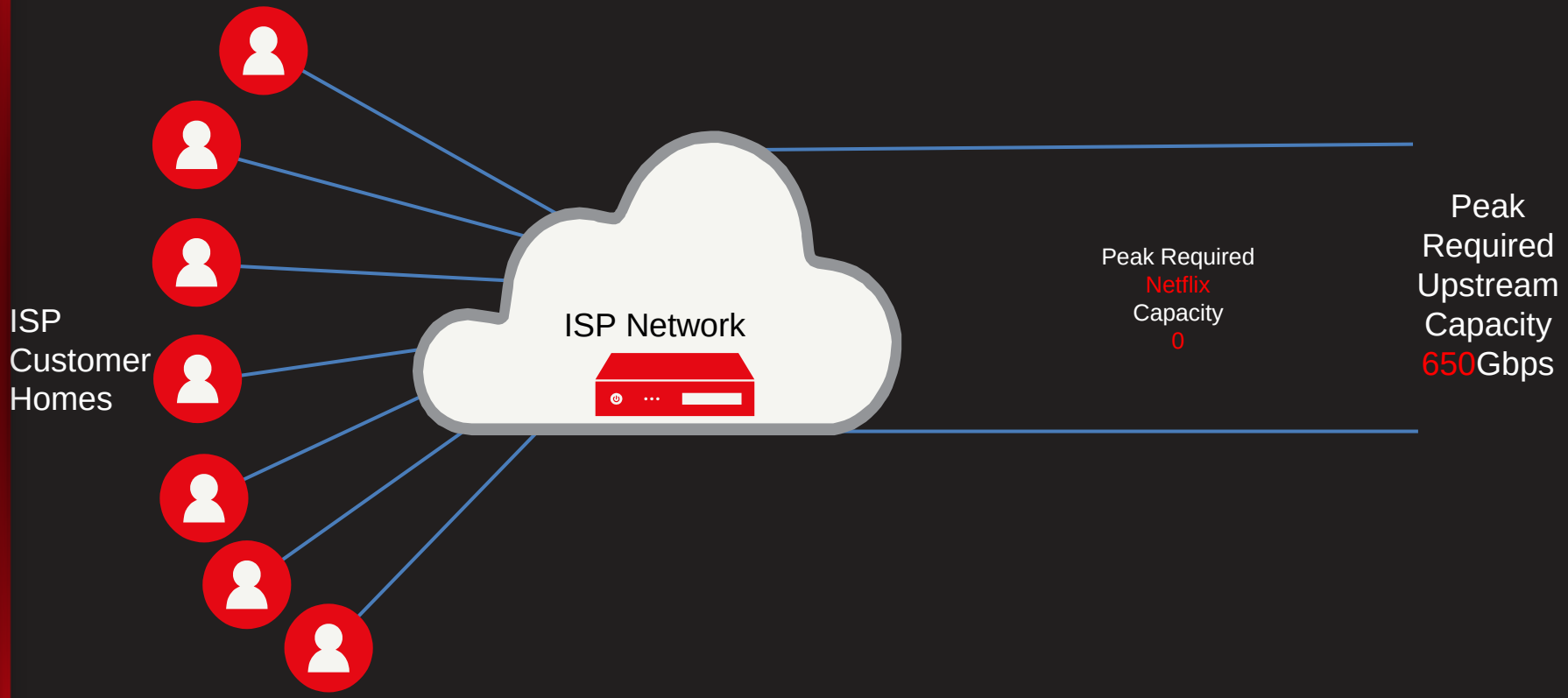
Path – India to US without CDN

```
Michaels-MacBook-Pro:~ mksmith$ traceroute www.seattleix.net
traceroute to www.seattleix.net (208.90.171.35), 64 hops max, 52 byte packets
 1  116.212.178.77 (116.212.178.77)  2.329 ms  1.834 ms  2.949 ms
 2  116.212.178.249 (116.212.178.249)  3.972 ms  4.143 ms  4.064 ms
 3  14.140.113.17.static-delhi-vsnl.net.in (14.140.113.17)  748.948 ms  771.170 ms  409.526 ms
 4  172.31.134.205 (172.31.134.205)  10.789 ms  5.410 ms  5.177 ms
 5  172.31.17.5 (172.31.17.5)  46.364 ms  50.330 ms  50.270 ms
 6  ix-ae-4-2.tcore1.cxr-chennai.as6453.net (180.87.36.9)  46.257 ms  41.833 ms  46.268 ms
 7  if-ae-5-2.tcore1.svw-singapore.as6453.net (180.87.12.53)  81.927 ms
 8  if-ae-11-2.thar1.svq-singapore.as6453.net (180.87.98.37)  77.703 ms * *
 9  ae-6.r00.sngpsi05.sg.bb.gin.ntt.net (129.250.8.241)  85.709 ms
    if-ae-20-2.tcore1.svq-singapore.as6453.net (180.87.96.21)  76.765 ms  77.891 ms
10  ae-10.r20.sngpsi05.sg.bb.gin.ntt.net (129.250.7.18)  83.449 ms  87.738 ms
    if-ae-7-2.thar1.svq-singapore.as6453.net (180.87.98.9)  86.922 ms
11  ae-6.r00.sngpsi05.sg.bb.gin.ntt.net (129.250.8.241)  85.608 ms
    ae-8.r22.snjsca04.us.bb.gin.ntt.net (129.250.3.48)  322.796 ms *
12  ae-10.r20.sngpsi05.sg.bb.gin.ntt.net (129.250.7.18)  83.925 ms  82.596 ms
    ae-0.r23.snjsca04.us.bb.gin.ntt.net (129.250.2.183)  357.662 ms
13  ae-3.r21.sttlwa01.us.bb.gin.ntt.net (129.250.3.125)  463.219 ms
    ae-8.r22.snjsca04.us.bb.gin.ntt.net (129.250.3.48)  264.568 ms  456.188 ms
14  ae-11.r04.sttlwa01.us.bb.gin.ntt.net (129.250.2.6)  432.273 ms
    ae-0.r23.snjsca04.us.bb.gin.ntt.net (129.250.2.183)  265.704 ms
    ae-11.r04.sttlwa01.us.bb.gin.ntt.net (129.250.2.6)  292.832 ms
15  ae-0.seattles-best-internet.sttlwa01.us.bb.gin.ntt.net (129.250.201.234)  462.328 ms  409.110 ms  369.230 ms
16  agg2-sea-a-t8-2.bb.spectrumnet.us (174.127.140.170)  331.954 ms
    agg2-sea-a-t9-3.bb.spectrumnet.us (174.127.140.182)  409.598 ms
    agg2-sea-a-t9-2.bb.spectrumnet.us (174.127.140.178)  613.817 ms
17  ae-0.seattles-best-internet.sttlwa01.us.bb.gin.ntt.net (129.250.201.234)  408.859 ms
    panang-lo.alt.net (208.90.168.253)  408.594 ms  285.578 ms
18  c5.seattleix.net (208.90.171.35)  293.153 ms  302.359 ms
    agg2-sea-a-t8-2.bb.spectrumnet.us (174.127.140.170)  360.460 ms
```

Path –Indian Site with CDN

```
Michaels-MacBook-Pro:~ mksmith$ traceroute www.airtel.in
traceroute to e8827.a.akamaiedge.net (23.57.211.88), 64 hops max, 52 byte packets
 1  116.212.178.77 (116.212.178.77)  2.816 ms  2.024 ms  2.197 ms
 2  116.212.178.249 (116.212.178.249)  3.985 ms  4.308 ms  3.975 ms
 3  14.140.113.17.static-delhi-vsnl.net.in (14.140.113.17)  7.198 ms  6.032 ms  14.787 ms
 4  172.31.134.201 (172.31.134.201)  5.244 ms  9.165 ms  6.477 ms
 5  172.23.183.161 (172.23.183.161)  26.592 ms  26.111 ms  26.083 ms
 6  115.113.165.130.static-mumbai.vsnl.net.in (115.113.165.130)  30.240 ms  30.421 ms  60.700
ms
 7  a23-57-211-88.deploy.static.akamaitechnologies.com (23.57.211.88)  29.895 ms  30.391
ms  29.807 ms
```


ISP
Customer
Homes
ISP Network
Peak Required Netflix
Capacity
350Gbps
Peak Required
Upstream
Capacity
1Tbps


ISP
Customer
Homes
ISP Network
Peak Required
Netflix
Capacity
0
Peak
Required
Upstream
Capacity
650Gbps

What CDNs don’t provide?

- Zero additional traffic prioritization
- Cost efficiencies for ”small” content providers

CDNs don’t provide

- Traffic continues to grow
  - Through subscriber growth, particularly mobile
  - Through increased use of Internet versus other delivery mechanisms
    - Entertainment
    - Non-entertainment
  - New technologies (virtual reality)
  - Ubiquitous access