The Internet Backbone Problem

Why the existing Internet prevents SaaS providers from delivering the best possible customer experience

Teridion
February 2017

Introduction

Asking Google about internet performance problems produces 249 million responses. The Internet makes it possible for anybody to access web applications but at the price of fair to middling performance for everybody.

In 1983, IBM researchers determined that employee productivity was directly linked to sub-second application response time. Yet in 2016, the percent of web applications that can actually deliver sub-

> "When a computer and its users interact at a pace that ensures that neither has to wait on the other, productivity soars"

IBM RESEARCH
1983

But, why exactly do web applications have such poor response time and what role does the Internet Backbone play in slow performance? This white paper explores the "Internet Backbone Problem," discusses some common workarounds and describes how Teridion Virtual Networks address fundamental Internet design issues.

The Internet: a SaaS Provider's Best Frenemy

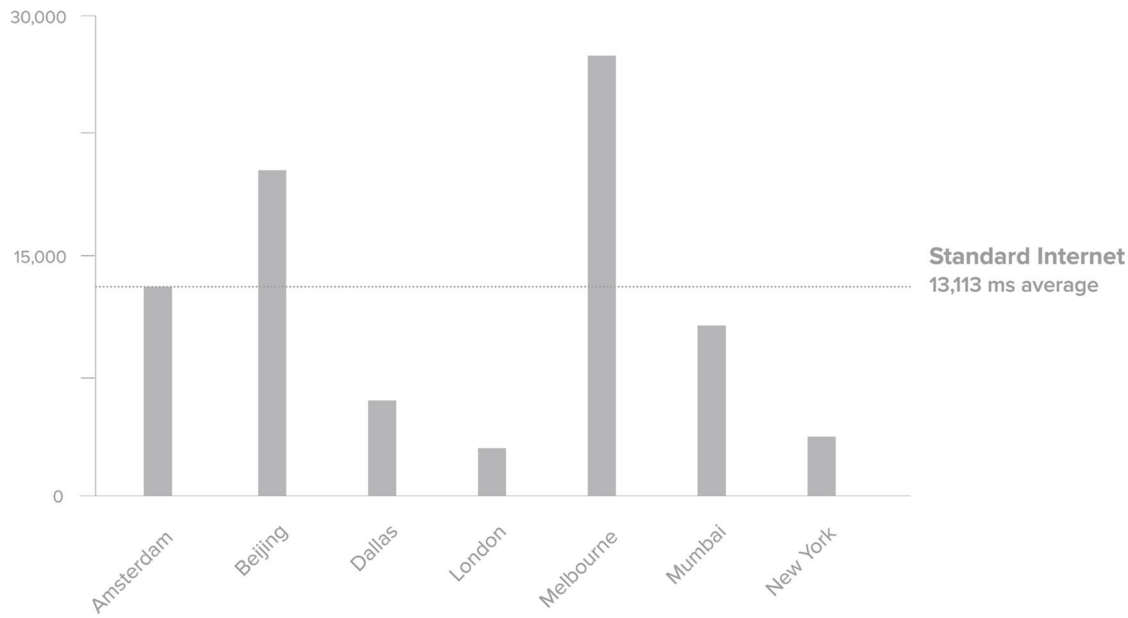
Early web applications such as ecommerce sites were effectively static product catalogs. These applications benefited greatly from Content Distribution Networks (CDNs) that moved static content such as catalog pictures to regional data located caches closer to end users.

Today, most SaaS applications include dynamic, personalized interactions and bi-directional content flows that are anything but static. This kind of data cannot be cached and must rely instead on more consistent Internet backbone performance. SaaS providers that are especially sensitive to Internet performance include:

- **Document Collaboration:** enterprise file sharing & synchronization, plus those that enable content sharing for regulated industries.

- **SaaS Application Performance:** collaborative applications with rich interactive features that must deliver consistent performance for global end-users.
- **Big Data ETL:** data analytic solutions that require timely transfer of very large files or logs.

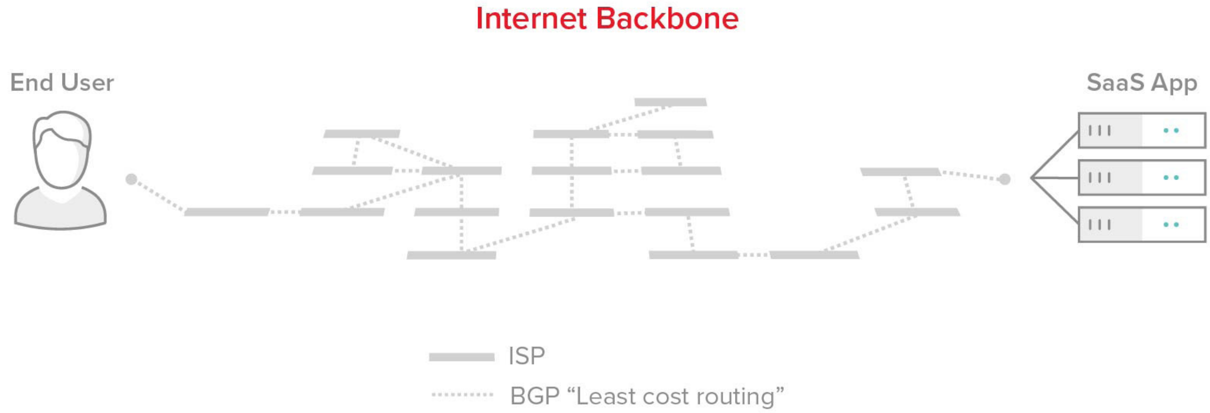
SaaS providers need these types of data transfers to be delivered consistently fast, regardless of where their origin servers and end-users might be in the world. As the SaaS customer base becomes more global, gaining control and visibility over inconsistent Internet backbone performance becomes more important. The chart below shows delays that global customers for a major collaboration SaaS provider experienced when trying to upload a 5 MB to a San Jose, CA data center.



As this chart shows, some end user uploads may only take a few seconds, while others might take almost 30 seconds. Why are SaaS providers unable to deliver a consistent experience to all of their customers, regardless of geography? To answer this question, we need to first understand what happens to data sent over the Internet between the time it leaves an origin server and is received by an end-user.

How the Internet Really Works

Nearly all web browsing, collaboration, photo & file sharing or video & music streaming traffic flows through the Internet Backbone. The Internet Backbone is made up of many large Network Service Providers which interconnect. These large networks charge ISPs to transport data packets long distances.



Content Providers

"Content Providers" can include any business that serves up data over the Internet like web pages (New York Times), video (Netflix), pictures (Instagram), VoIP (RingCentral), online gaming (Electronic Arts), a SaaS application (Box or Salesforce), or music (Soundcloud). For collaborative web applications, end users provide dynamic content to each other (Slack or Skype).

Internet Backbone

In 1986, the U.S. National Science Foundation (NSF) established the first backbone network for the Internet which only provided up to 56 Kbps. The Internet today is a collection of independent network providers that tap into the biggest backbones owned by companies like AT&T, Verizon, Sprint and CenturyLink. It consists of routers and switches, connected mainly by fiber optic cables, with each fiber link on the backbone normally providing 100 Gbps of bandwidth.

Backbone providers in-turn sell access to their networks to companies who ultimately sell access to the Internet to businesses and end-users. It is almost always the case that a content provider won't be willing to pay the costs associated with connecting to the Internet Backbone directly, and will instead connect indirectly via an ISP, Tier 1 or 2 network provider.

Tier 1 Networks

Tier 1 providers have comprehensive networks that permit them to never have to purchase transit agreements from other networks. Meaning they can typically reach any two points on the Internet without having to pay for the routes of another network provider. There are roughly a dozen Tier 1 providers including companies like Level 3, Telefonica, NTT and Deutsche Telekom. These providers make money carrying traffic for other ISPs.

Tier 2 Networks

Tier 2 providers peer with some networks, but still purchase IP transit rights or pay settlements to Tier 1 providers to reach at least some portion of the Internet. Examples of Tier 2 networks include British Telecom, Virgin Media and Hurricane Electric.

Internet Service Provider

Internet services typically provided by ISPs include Internet access, transit, domain name registration, web hosting and colocation. Examples of ISPs include Comcast, Cox and AT&T. These providers make money connecting residential and commercial customers and end users to the Internet Backbone.

End User

In this case we are talking about an end user connected to the Internet via a wired, WiFi or mobile connection. This might be a business user or consumer connecting to the Internet via a fast connect through the corporate LAN or to a WiFi router in their residence. Ultimately, it is the end-user on the receiving end of the either good or bad performance that the Internet delivers.

Economics of the Internet Backbone

The Internet is a collaborative business venture between many different network operators. Whenever a provider needs to send data across a network it does not own, it sends that traffic to another network via:

1. A peering agreement or
2. A transit agreement

Peering Agreements

Backbone providers who move roughly equivalent amounts of traffic regularly create agreements called "peering agreements," which allow the use of another's network to hand off traffic where it is ultimately delivered. Usually they do not charge each other for this, as the companies get revenue from their customers regardless. For example, Verizon may need to access a CenturyLink network to deliver its customer's data, but won't be charged for doing so because they have a peering agreement. The obvious incentive here is for CenturyLink to transport Verizon's data at the cheapest possible cost, not the fastest route.

Transit Agreements

Backbone providers of unequal market share usually create agreements called "transit agreements" that usually involve some sort of monetary agreement. For example British Telecom may need to access an AT&T network to deliver its customer's data, but in order for that to happen it needs to have a transit agreement in place. In order to maximize profit, the incentive here is for AT&T to transport British Telecom's data at the cheapest possible cost, not the fastest route.

Here is a description of how ISP payment arrangements work: your ISP pays a bunch of other (usually bigger) ISPs (And those ISPs pay a bunch of other ISPs).

ISP 1: *"Hey, can you handle some of my internet traffic?"*

ISP 2 (bigger): *"Sure, if you can handle an equal amount of mine."*

ISP 1: *"Can't handle your data, I'll pay you instead"*

ISP 2: *"Great."*

The Internet Backbone Problem

In this section we'll look at why the economics of the Internet Backbone and the technology it depends on creates problems for SaaS providers looking to deliver a consistently fast customer experience. These Internet issues aren't mistakes, but design trade offs that were made 30 some odd years ago. For SaaS providers however, these tradeoffs have come at the expense of performance, as there is no way an individual organization can fix the Internet Backbone on their own.

How Least Cost Routing Hurts Performance

Least cost routing is the process of selecting the path traffic will take along the Internet Backbone based on the lowest cost, not on performance. Least cost routing happens as a result of the rules that are baked into Border Gateway Protocol (BGP), the routing protocol of the Internet Backbone. These BGP rules prioritize traffic on the number of networks the traffic has to pass through to reach its destination and on cost-based weighting factors.

Because network providers are for-profit endeavors, they will always opt to send data along the lowest cost paths. For SaaS providers, this means there is no way to pay more to get a better quality of service on the public Internet Backbone. This puts the customer experience for SaaS providers at the mercy of the network providers cost-cutting routing tables.

How BGP Hurts Performance

BGP is what network providers use to route data from their own machines to others, and vice versa. When you visit a website, that data traverses networks all over the world, through machines belonging to all manner of companies and organizations. In order to ensure that data transmissions eventually get to their intended locations, routers keep a table of known, trusted routes.

Each router is part of an Autonomous System (AS) with its own Autonomous System Number (ASN). The relationship between IP addresses and ASNs are similar to the relationship between street addresses and zip codes. Just as the postal service uses only the zip code to route mail, the Internet uses the ASN to route traffic. Only when a packet is delivered to the proper ASN does the network pay attention to the IP address.

Within the BGP protocol, only the ASN associated with an IP address is used for routing. BGP rules dictate that each packet will be routed to the route with the fewest number of ASN “hops” (this is called the route with the shortest AS_PATH).

The negative performance impact to SaaS providers of the Internet relying on BGP is that the protocol’s rules for moving traffic between networks (called EBGP) dictate that traffic between two points will always take the same path regardless of network congestion.

How TCP/IP Hurts Performance

Among routing protocols, BGP is unique in using Transmission Control Protocol (TCP) as its transport protocol. TCP/IP provides the Internet with reliable, ordered and error-checked delivery of data between two systems. It can't be stressed enough, that TCP/IP is optimized for accurate delivery rather than timely delivery and can incur long delays (often for seconds) while waiting for out-of-order messages or retransmissions of lost messages. For this reason, real-time applications like VOIP opt to use different protocols.

The negative impact for SaaS providers is that the TCP/IP data transfer algorithms are not designed to be efficient. TCP/IP requires each chunk of data to be acknowledged by the receiver before the sender sends the next batch of data. Since these data chunks are typically small, typically a thousand bytes, it means that transferring even 1 MB of data can require hundreds of separate trips through the Internet Backbone.

Internet Backbone Problem Workarounds

SaaS providers attempt to fix their Internet Backbone problems by implementing expensive and complex workarounds including the building replicated data centers to improve performance for regional end users. In this section we look at pros and cons of each solution and why they all fail at solving the real reason why Internet performance is slow or inconsistent.

Use a CDN to Eliminate Internet Backbone Traffic

Content Delivery Networks (CDNs) are distributed servers that serve cached content to users based on their geographic location. CDNs are excellent for serving static content to users near the CDNs Point of Presence (PoP), but quickly become impractical for handling dynamic data that must created "on the fly." Popular CDNs include Akamai, Amazon Cloudfront and CloudFlare.

Some CDNs have built fiber backhaul networks between their PoPs to help refresh cache contents. These backhaul networks can be used to help accelerate uploads and bi-directional content, but these networks were optimized to refresh static data and often don't perform as well for accelerating dynamic content.

Deploy Regional Data Centers

Some SaaS providers create regional data centers to improve performance, locating PoPs in the geographies where users are experiencing poor performance. For example, if users in Sydney, Australia are experiencing poor performance, the SaaS provider will either deploy storage and application servers to a Sydney cloud data center, or in some cases build out an entire data center themselves.

This approach works when the company can absorb the complexity and cost of deploying and running their own data centers and maintaining mechanisms to synchronize data across many distributed systems. However the business complexity created by such an architecture creates significant lock-in and prevents SaaS providers from being able to roll out new features and technologies quickly.

Deploy SD-WANs

Software-Defined Wide Area Networks (SD-WANs) are corporate WANs that have been virtualized with software. SaaS vendors with regional data center PoPs must also deploy backhaul networks between the PoPs to synchronize data. They must also contend with inevitable customer issues related to out of date information between data centers.

A Real Solution to the Internet Backbone Problem

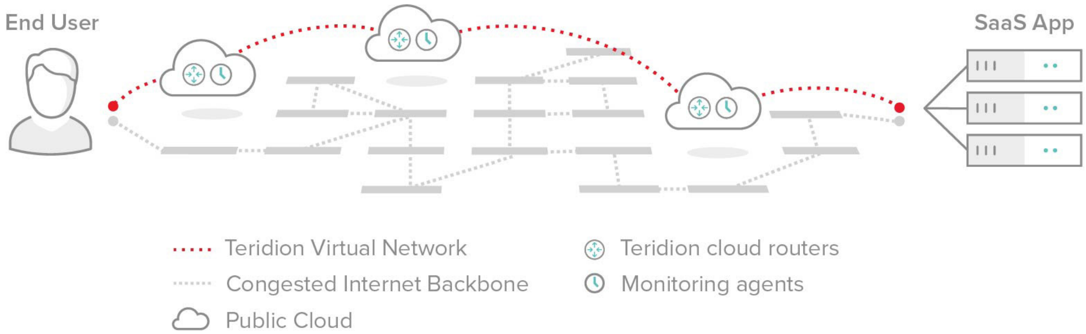
Teridion opens up a fast lane through the Internet that gives the end-users of SaaS providers sub-second application performance around the globe. The Teridion Virtual Network routes traffic around the congested networks in the Internet Backbone, thus eliminating the need for workarounds. This in-turn reduces the cost and complexity of application, storage and networking infrastructure.

The Teridion Solution

Teridion's Virtual Network intelligently analyzes the Internet Backbone to find the fastest routes between any two endpoints, avoiding congestion and overcoming the performance problems caused by least cost routing. In the process it delivers 20x better data transfer performance. Teridion is deployed across public clouds and delivered "as-a-Service," so there is no hardware or caching to configure.

How Teridion Works

Teridion's virtual network is comprised of three components deployed globally across public clouds:

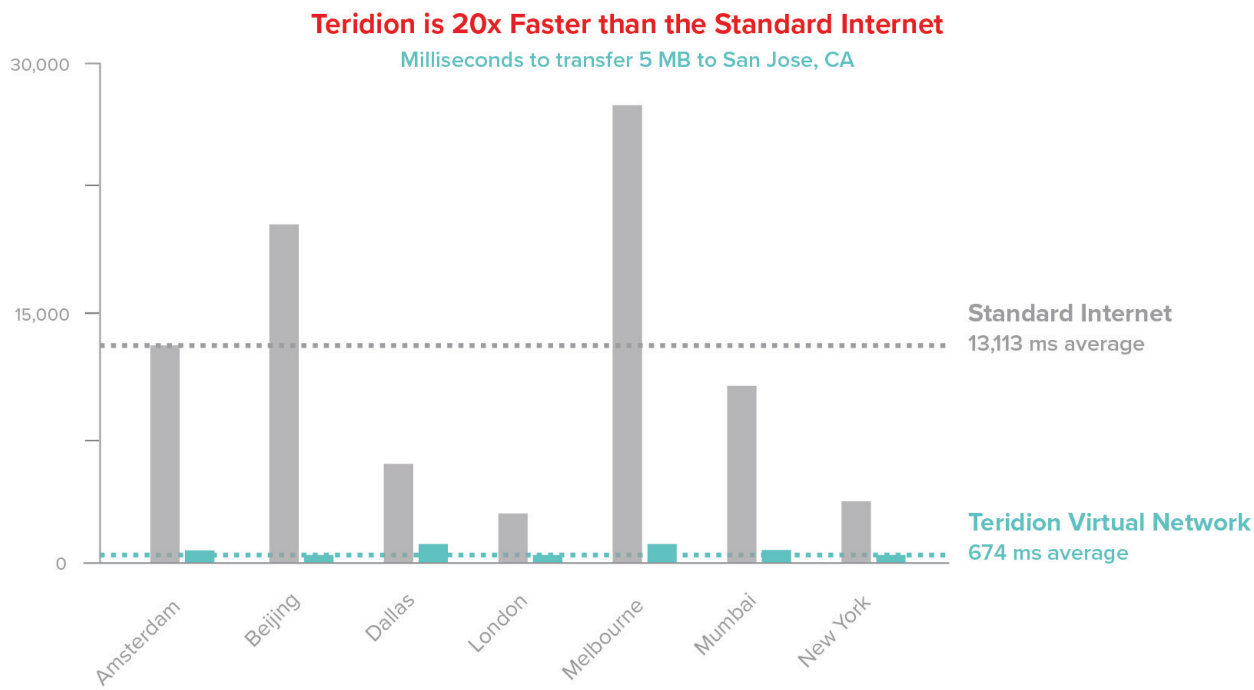


1. **Teridion Monitoring System:** The TMS is comprised of virtual agents running in hundreds of public cloud data centers that are constantly calculating the fastest path between any two points.
2. **Teridion Cloud Routers:** TCRs are virtual routers running in public clouds that direct traffic along the fastest paths.
3. **Teridion Portal:** A management UI for network administrators to manage traffic and troubleshoot connectivity issues.

> "Wherever web performance problems occue, we sprinkle Teridion Virtual Networks like pixie dust and watch as our Internet issues magically disappear."

VINEET JAIN
CEO, Egnyte

Results of Implementing Teridion



Conclusion

The Internet Backbone's economics and protocols make it challenging for SaaS providers to deliver sub-second response times to end users who are located far from the application's data center. But by better understanding why the "Internet Backbone Problem" exists, why potential workarounds fail to address the core problem and how Teridion addresses the fundamental reasons why the Internet is slow, a SaaS provider can actually realize the customer experience they strive to deliver to their users, every time.

Next Steps

- Start a FREE Trial: Contact us.
- Questions: Contact us.
- Case Studies: Learn how SaaS providers are succeeding with Teridion
- Datasheets: Learn more about Teridion
- Whitepaper: “Internet Backbone Problem”

Further Reading

- More on How the Internet Works
- How Internet Backbone Payments Work