White Paper

Turn the Green Light on the Last Mile: Optimizing End-User Experience in a Web 2.0 World

Introduction

The first wave of Internet technology revolutionized the way business is conducted, but the next wave, known loosely as Web 2.0, promises to do even more. The Internet is being reinvented, morphing into a medium capable of delivering extremely interactive and rich experiences. While this next wave of Web sites and experiences holds significant promise in terms of customer retention, interaction, and revenue growth, it also poses new challenges. Users have come to expect excellent technical quality online, and sites that do not provide a consistent performance experience, one free of errors, variability, and technical issues, are seeing their market share erode because users can easily move to competitors. A poor online experience thus translates directly to less satisfied users, poorer brand perception, and higher costs (including offline servicing costs, among others).

Sites that have mastered Web 1.0 technologies are now facing new technological hurdles as well. These new, richer, and more interactive experiences require the use of new technology and architectures. The framework for Web 2.0 sites is being created from technologies like Flash, Silverlight, and AJAX and with services like Content Delivery Networks, outsourced Web services, and personalization and publishing engines.

The combination of new technology and higher user expectations creates significant challenges to managing the online experience. It is becoming much more difficult to understand the user experience, let alone deliver a high-quality experience. Site owners can no longer rely on simplistic data center measurements of uptime or server performance to understand their end users' experience. No longer will measurements of single pages provide a view into the end-to-end performance of the user online.

Instead the challenge must be met with measurements that realistically capture the end-user experience, not from the data center, but from where the user resides, on the Internet and more specifically on the "last mile" where users connect to Internet services. Keynote has found that the quality of the core of the Internet has improved dramatically over time. The same cannot be said for the last-mile experience. Understanding the trends in the last mile, the factors that affect last-mile performance and how to implement a measurement strategy that captures this last-mile experience are key to delivering a high-quality experience online.

This white paper will:

- Discuss important emerging Web trends and their influence on the end-user experience
- Analyze the various last-mile access types and their impact on end-user experience
- Examine broadband in detail and the implications for online businesses
- Outline important ways to reliably monitor last-mile performance

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1. First, Middle, and Last Mile Defined

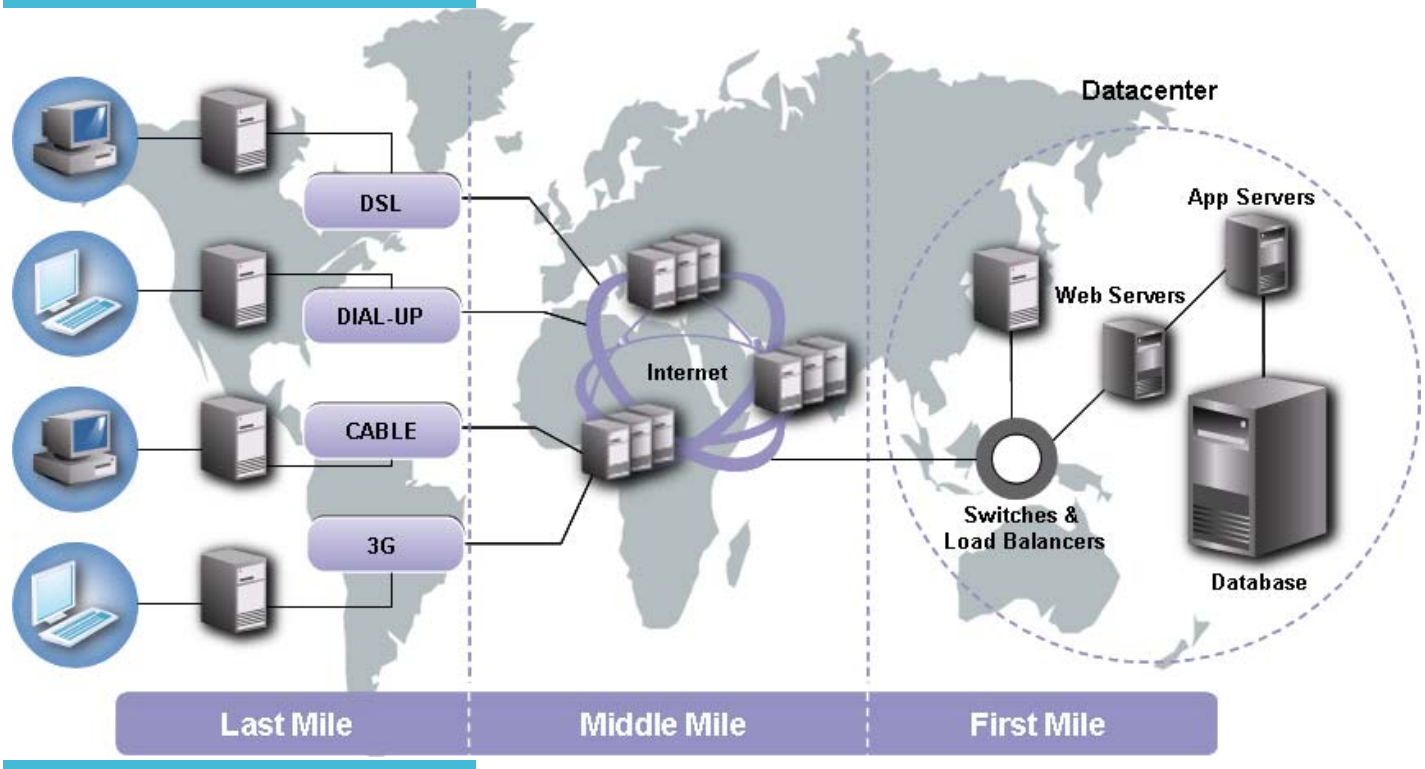
The infrastructure for providing services to the end user can be divided into:

- First mile
- Middle mile
- Last mile

The first mile consists of the infrastructure (data center, point of presence) that houses the content of a Web site/Web applications. Performance measurement of the first mile is important for understanding the effectiveness of the data center infrastructure. However, this measurement is not at all indicative of the end-user experience. This is especially true because a modern site is a collection of third-party content and Web services that do not reside in one single data center.

The middle mile is a collection of high-bandwidth backbone providers, sometimes known as the Internet "core," which together form the central delivery mechanism for the entire Internet. Broadly termed the Internet, the middle mile is a good place to test sites and Web applications for performance and availability. The middle mile is very stable, and measuring middle-mile performance is a good way to determine the user experience without introducing extra "noise" or variables that are harder to control for.

The last mile is the link between the middle mile (or core) and the end customer via services such as DSL, cable, dial-up, and 3G. This is the final linkage between the Internet and the customer's home. Unlike the middle mile, where quality has improved consistently over the years, last-mile performance problems continue to affect the end-user experience.



2. Industry Trends and Last-Mile Impact

The Web has become a hotbed of innovation focused on increasing Web site and Web applications' "stickiness." Web 2.0 technologies are playing an increasingly important role in customer acquisition and retention. Companies are constantly looking to leverage new technologies, such as broadband video and social networking, to give consumers a more interactive experience. For example, Nike allows users to customize their footwear with preferred colors online, using a single-screen for the multistep configuration process. Auto manufacturers' sites showcase models in day-in-the-life settings that reveal the car's features from the users' perspective, allowing users not just to consume but also interact with multimedia.

User-generated content (UGC), also known as consumer-generated content, is online content that is created exclusively by users. Traditional media, such as broadcasters and production companies, in this case do not play a role in Web site content creation. The content may be monitored by administrators to avoid offensive content or language or just to ensure that the content is relevant to the Web site. The Web sites are partially or completely constituted by UGC. For example, in Amazon.com the product specification and other details are added to the Web site by the administrators, while the users add product reviews of the products they have purchased.

Given a dynamic, globally connected marketplace, and increasingly mobile workforce, enterprises have also come to depend on the Web as a central business component, including operations, communications, sales, marketing, support, and human resources. While Web 1.0 saw a migration to outsourced applications (ASPs), the emergence of Web 2.0 technologies (service-oriented architectures, Rich Internet applications [RIAs], and social networks) has accelerated the migration of work from the desktop to the "webtop."

2.1 The Online Consumer

An IDC study on consumer online behavior revealed that out of the total time spent per week by consumers on media consumption, the majority of the time (32.7 hours/week) is spent on the Internet.[1] This is twice the time spent on watching television (16.4 hours). Whether for travel or retail or financial services, the consumer is increasingly using the Internet to buy products and services online.

For example, in the online travel industry, the UK, Germany, and France account for about 62% of the total online travel expenditure in Europe according to an EyeForTravel report.[2] A Deloitte and Touche Online Travel Survey noted that in the US, 77% consult online reviews (increasingly, their friends on Facebook) before making purchases. [3] Forrester Research found that 94% of U.S. business travelers and 88% of U.S. leisure travelers are online, making air travel the top travel product booked online in the U.S.[4]

Online retailers in the U.S. saw a 21% increase in sales to $175 billion in 2007. This amount is expected to cross the $300 billion mark to $334.7 billion by 2011 according to Forrester Research.[5]

As for financial services usage by consumers, Forrester Research indicates that with the S&P 500 increasing 5% per year, the adoption of online trading

in the U.S. will increase by 32% to 12 million U.S. households making at least one trade online per calendar year.[6]

With Web 2.0, the interactive nature of the services provided online has become an integral part of consumers' lives.

2.2 Web 2.0

Web 2.0 is technology, methodology, and applications rolled into one. Web 2.0 promises substantial gains over older communication tools in the areas of interaction and relationship building and in creating applications that are composed of others. While AJAX and Rich Internet applications (RIAs) are two of its core technologies, social networking and mashups represent two techniques that are being increasingly adopted in the development community. With the increase in social networks UGC is playing an important role in providing the content of the many Web sites.

2.2.1 Broadband Video

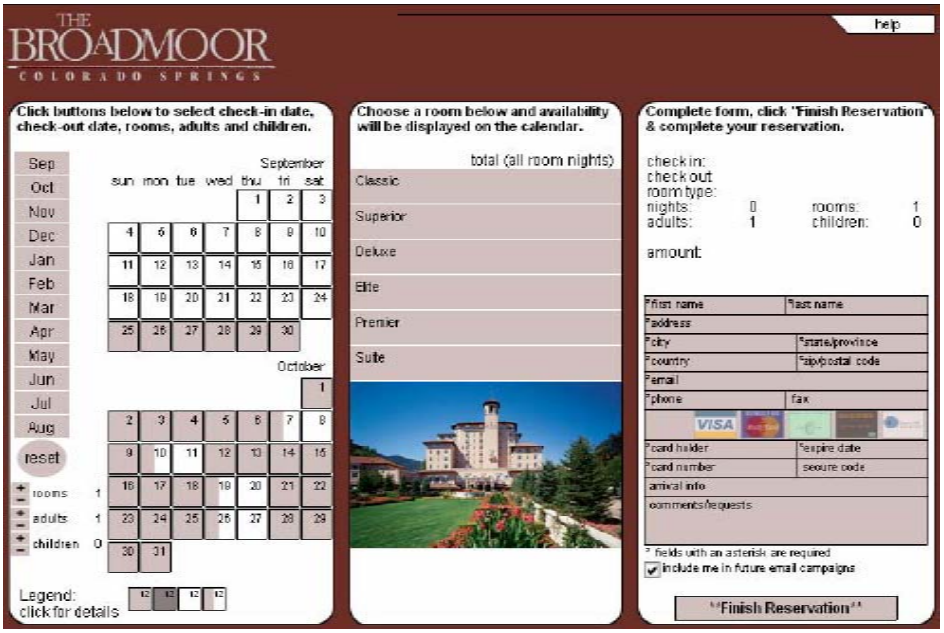
Large numbers of users now routinely watch videos online that are either user generated video or branded video content.

User-generated video or UGV is online video content contributed exclusively by the users. According to Accustream Media Research,[7] a total of 22.7 billion UGVs were viewed in 2007—an estimated 70% increase. The market is expected to grow at 52% and reach 34 billion views by the end of 2008. Sites like Metacafe and Youtube are prominent hosts for UGV content.

Branded video content is online video made exclusively in order to promote a brand. MySpace launched MySpace Video, which hosts branded video channels with content from the New York Times, Reuters, National Geographic, Young Hollywood, Flow, Expert Village, and Octane TV, among others. Companies today are engaging audiences through broadband and related technologies to increase brand loyalty and generate sales.

2.2.2 AJAX and Rich Internet Applications

RIA architectures reflect the gradual transition of Web applications from the simple thin-client Web browser to a richer, distributed-function paradigm that behaves more like the desktop in a client/server model. These richer user experiences are being implemented using "client-engine" technologies like Flash, AJAX, and Java using standard Internet and Web protocols. For example, AJAX-based RIAs let customers measure and report on logical pages that are entirely different from the underlying physical page or pages, leading to a better customer experience.



The Broadmoor Hotel does everything in one page with AJAX, including search, information, selection, and fulfillment.

Appendix 1 highlights the key differences in the amount and type of data transferred across the Web for different technologies such as HTML, AJAX, and Flash.

2.2.3 Social Networking

Social networking sites like Facebook and MySpace are also rapidly gaining in popularity. According to a Forrester Research report,[8] one in five online young adults in the U.S. use social networking sites daily. According to another Forrester report,[9] 86% of online European youth are engaged in social networking. Most of these sites produce revenue through advertising, but they're also creating new business models.

2.2.4 Mashups

Mashups are combinations of applications. Flickr is an example of a photo and map mashup enabling users to store and share photos. Using the mashup, the users can place their photos on a Flickr generated map, indicating where they took them. Users can view the photos taken by other Flickr members in different parts of the world using this mashup.

BidRobot is an example of shopping mashup. It is a tool that makes bidding on eBay more effective for users. This mashup automatically submits bids on eBay on the user's behalf during the final moments of an auction. This lets

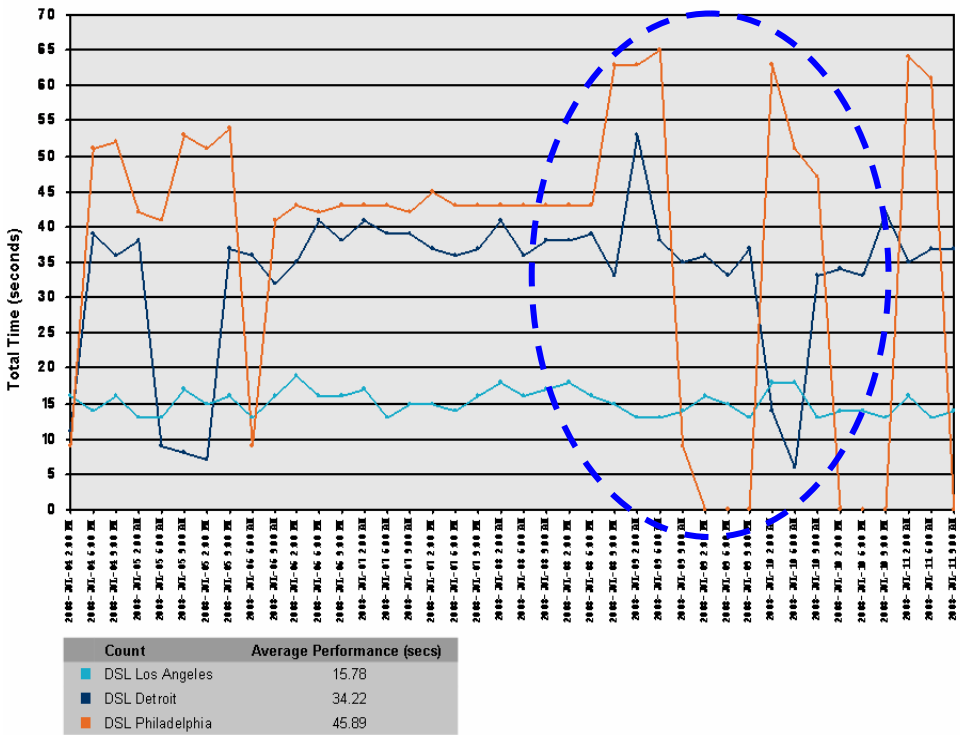
users hide their interest in a product, enabling them to place lower winning bids and save money.

2.2.5 High-quality user experience is a challenge

Many Web 2.0 technologies (such as AJAX, Silverlight, Flash, JavaFX, and Flex) make Web sites and Web applications rather complex and difficult to monitor with centralized server tools. Ensuring a high-quality end-user experience is thus becoming a challenge.

The graph below shows the variation in response times of DSL users from three different locations in the U.S. for downloading the same Web site. The Web site accessed here is an automotive manufacturer's site with heavy Flash usage, video, and a mashup with dealer locations. The home page size is 650Kb.

As seen in this graph, users accessing the Internet via DSL in Philadelphia experience extremely slow response times (average response time: 45.89 seconds) as compared to DSL users in Los Angeles (average response time: 15.78 seconds). There were six instances in 24 hours where service was not available or the response time was more than 60 seconds. The response time continued to fluctuate during the next day, thereby increasing the probability of Web site abandonment by users. During a new car model launch, high traffic would be expected on an automotive manufacturer's site. Therefore sales conversions and the brand can be affected by poor performance of the last-mile network, as in this case of poor DSL performance in Philadelphia. While the penetration of high-speed and broadband Internet access is increasing, "last-mile performance" still has significant business impact.



Source: Keynote Systems, Inc.

An average Web site takes 2–3 seconds to load. According to Apdex.org, as the load time increases to 4–6 seconds, users start to get frustrated. The level of frustration and the probability of switching to another Web site increases if the load time goes beyond 6 seconds.

2.3 Business Impact

The challenge in the Web 2.0 world is to keep meeting or exceeding consumer expectations and deliver growth in a complex technology environment.

For revenue-generating sites, like online retail, the key to online business success is the "money path" – the set of online steps that a user navigates to complete a transaction. It is only on completion of these steps that the visitor's intention to purchase is converted into an actual purchase and revenue. Poor accessibility and uneven quality of the transaction experience can have a major impact on revenue and return usage.

Many sites do not directly generate revenue, unlike a retail site or travel site, but instead focus on customer service. Sites like credit card, banking, and insurance sites reduce costs, cross-sell products, and help increase customer loyalty by servicing customers online. A poor experience directly translates into increased calls to the call center and a decrease in overall customer satisfaction.

In the case of online trading sites, online performance is extremely critical. A delay of seconds carries the risk of huge trading losses, and an equally large litigation and regulatory risk.

For brand marketer sites, a poor experience online translates to lost leads and poor brand perception. In many cases, users draw correlations between a poor online experience and the product or service being marketed.

Not only does a technical issue (poor performance, outages, and errors) impact the direct customer or user, it can also have ripple effects. Large outages are now discussed not only in traditional media (newspapers and television) but by users on social networking sites who "rant" about their poor experience online, causing the impact of an issue to linger much longer than the actual event due to negative word of mouth.

Technical quality can no longer be an afterthought, because so much is riding on providing a technically sound performance experience online. Loss of revenue, lower customer satisfaction, negative brand impact, and higher costs can be tied directly to poor technical quality. The unique challenges of Web 2.0 technology therefore make it imperative for the site owners to ensure the quality of not only their first- and middle-mile performance but their last-mile performance as well.

3. Last Mile

Three main access mechanisms are used in the last mile. They are Broadband, 3G, and dialup

The last mile has moved over the last several years from dialup connections to broadband; in addition, 3G connections are spreading the use of the mobile Internet.

In 2007, the U.S. broadband market added 9 million household subscribers amounting to a total penetration of 70%. This trend is expected to continue.[10] On the other hand, total broadband penetration in Europe is about 83%. Broadband adoption has grown in Europe from 44 million households in 2005 to 85 million in June 2008, an increase of 95%.[11]

Fiber to the home (FTTH) is the latest form of broadband technology adoption. It is gaining traction, especially in population-dense areas. According to HeavyReading,[12] worldwide FTTH deployment is expected to grow to 89.6 million households by 2012. Asia continues to have dominance in the world FTTH market. According to FTTH council,[13] Asia accounted for a more than 27 million of the total 32 million FTTH connections worldwide by June 2008. South Korea tops the list with nearly 37% of its households connected via fiber. Hong Kong and Japan are at 27% and 24%, respectively. Even though the U.S. comes in third with 3.3 million FTTH households, it ranks 10th in the global ranking with 2.9% FTTH market penetration. A report by Frost & Sullivan reveals that there were 2.5 million FTTH households in Europe in 2006, a number that is projected to grow to 14.0 million by 2012.[14]

Worldwide 3G mobile data card sales are expected to reach $2.9 billion in 2011, nearly quadruple 2007 sales. The worldwide number of 3G mobile data card subscribers is expected to reach 144 million by 2011 according to Infonetics Research.[15]

3.1 Last mile: the variables

Although performance characteristics vary for each access type, geography and congestion play equally important roles in determining perceived end-user performance across broadband, 3G, and dialup access types.

According to the Federal Communications Commission, broadband is basic data transmission speed between 768 Kbps and 1.5 Mbps in at least one direction: downstream (from the Internet to the user's computer) or upstream (from the user's computer to the Internet).[16] Higher speeds help provide the consumer with ample infrastructure to support activities in various fields like education, public safety, and entertainment, etc. Broadband access is not completely free of performance issues, however – AJAX and mashups usually result in multiple trips to the server. While Flash and video increase the size of the files transferred, broadband can also experience poor response times due to congestion. Digital subscriber line (DSL), FTTH, and cable all form part of the broadband network.

3G or Third Generation wireless service is an International Telecommunication Union (ITU) specification that refers to the third generation of mobile communications networks. A 3G access card enables broadband access on the user's laptop through a mobile service provider's

data network. This includes a more robust connection for accessing the Internet and the ability to send and receive large e-mails and download attachments. The level of service for Internet access is highly dependent on cell signal quality.

Dialup connections use a telephone line connected to a computer to link to the Internet. Since a telephone line is used as the last-mile access solution, bandwidth limitations further degrade the end-user experience. Dialup is the slowest connection type, offering download speeds of less than 56 Kbps, and is therefore the least preferred access type.

3.1.1 Performance characteristics

Each of these last-mile access mechanisms has different performance characteristics.

The table outlines different access types and their variation in performance. For dialup connections, performance is completely linear to the size of the pages or files on the page – the larger the page, the poorer the performance. Flash and video are challenges to deliver across dialup. FTTH provides unlimited bandwidth but is expensive to deploy.

3G and dialup network service are more susceptible to bandwidth constraints rather than multiple roundtrips to the server. On the other hand, DSL and cable service are more affected by roundtrips than by bandwidth availability. With cable, bandwidth is shared with other subscribers in the neighborhood, so performance deteriorates as the number of users increases.

	Dialup	DSL	Cable	FTTH	3G
How It Works	Telephone line is hooked up to the computer instead of a phone	Shares space with your phone line	Connected through your cable TV line	Connects with the optical fiber to the home	Connects through 3G access card
Bandwidth	56 Kbps	768 Kbps–6 Mbps downstream, up to 512 Kbps upstream	Up to 6 Mbps downstream, 128–768 Kbps upstream	2–155 Mbps, 1G	128 Kbps – 2 Mbps
Reliability & Availability	Reliable but availability not good	Distance sensitive	Depends on users in neighborhood	Highly available	Secure mobile commerce transaction
Network Speed	Very slow	Very fast (if close to Central Office)	Fast	Very fast	Slow
Advantages	Secure and safe	High speed, low cost	High speed, low cost	Unlimited bandwidth	Wireless Internet, video conferencing
Disadvantages	Very slow	Speed decreases as the distance from exchanges increases	Shared medium	Very costly	Technology and the maintainance are more expensive; sensitive to cell signal qualilty

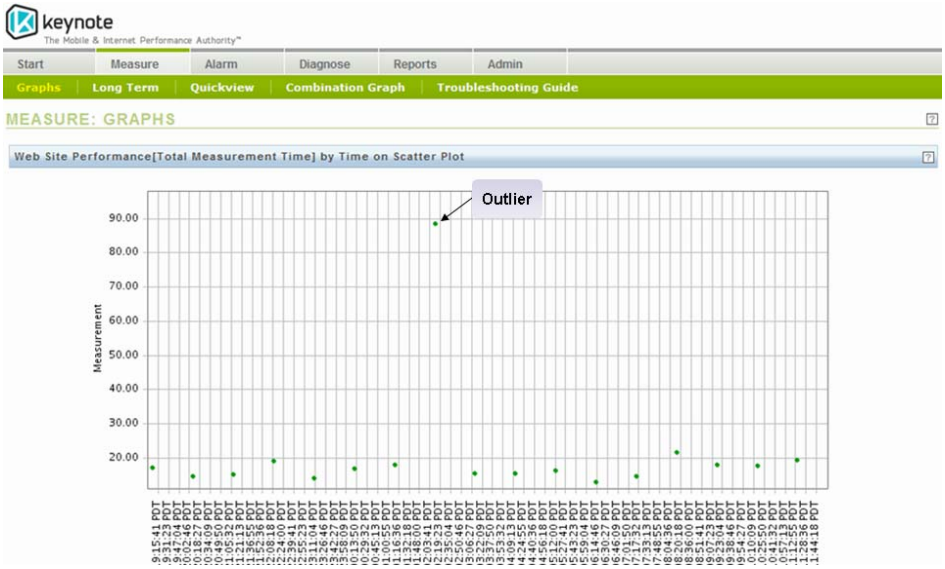
The following example helps illustrate the challenges of delivering consistent last-mile performance. Transactions are performed on a Flash-intensive Web 2.0 site using different last-mile access types. The download time for each access type is noted and the results are depicted in the graph below.

Source: Keynote Systems, Inc.

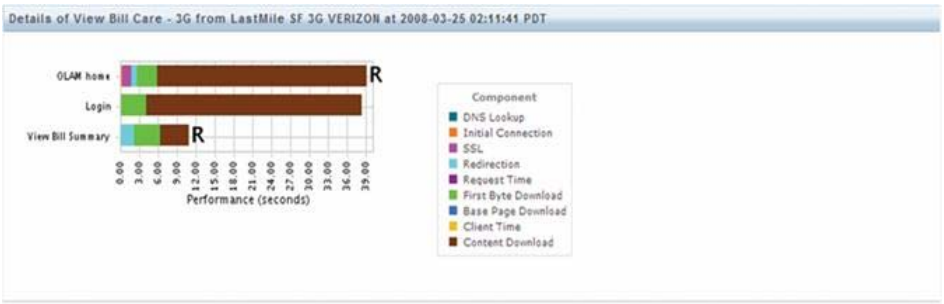
The user accessing the site via a T1 (the middle mile) connection experiences an average download time of 8 seconds. The service is stable with minimum fluctuations. DSL users accessing the same Web site experience an average download time of 11 seconds. Dialup users have the worst experience, with an average download time of 64 seconds and comparatively higher fluctuations in service quality.

With an average download time of 21 seconds, 3G users did not only experience slower performance than T1 and DSL users but also a significant slowdown of 89 seconds. This leads to an unsatisfactory end-user experience and possible abandonment of the Web site.

The graph (showing each individual measurement) below analyzes 3G last-mile service. The outlier points to the leap in download time in the 3G network of 89 seconds. The slowdown of the 3G carrier network is leading to longer download times.



Source: Keynote Systems, Inc.



Transaction Page Single Measurement

Transpage	View Bill Care - 3G					
	OLAM Home		Login		View Bill Summary	
User Components	Avg. Time (secs.)	%	Avg. Time (secs.)	%	Avg. Time (secs.)	%
Time to Opening Page	7.297	18.47	4.109	10.63	6.297	57.57
Page Download	32.218	81.53	34.547	89.37	4.641	42.43
Network Components	Avg. Time (secs.)	%	Avg. Time (secs.)	%	Avg. Time (secs.)	%
DWS Lookup	0.002	0.01	0.000	0.00	0.000	0.00
Initial Connection	0.251	0.64	0.000	0.00	0.000	0.00
SSL	1.545	3.94	0.000	0.00	0.000	0.00
Redirection	0.837	2.13	0.000	0.00	2.250	20.81
Request Time	0.000	0.00	0.000	0.00	0.000	0.00
First Byte Download	3.226	8.23	4.101	10.68	4.017	36.98
Base Page Download	0.018	0.05	0.004	0.01	0.003	0.03
Client Time	0.003	0.01	0.000	0.00	0.003	0.03
Content Download	33.339	85.00	34.309	89.31	4.579	42.16
Total Measurement Time	39.221		38.414		10.862	
Average Bytes Downloaded	117354		85863		13122	
Data Points	1		1		1	

Source: Keynote Systems, Inc.

Additional data let us delve further into the cause of the leap. The diagram above indicates the breakup of the time taken for the complete transaction as well as for the individual pages that make up the transaction using 3G access. Here the transaction comprises three different pages: the home page, a login page, and a view bill summary.

Out of all the activities required to generate a page, content download took the majority of the download time, as highlighted in the table above. The home page download took 33.3 seconds to complete. Login took 34.3 seconds. Even though the view bill summary took only 4.5 seconds to download, the complete content download required 72 seconds. This leap in download time leads to higher instances of Web site abandonment.

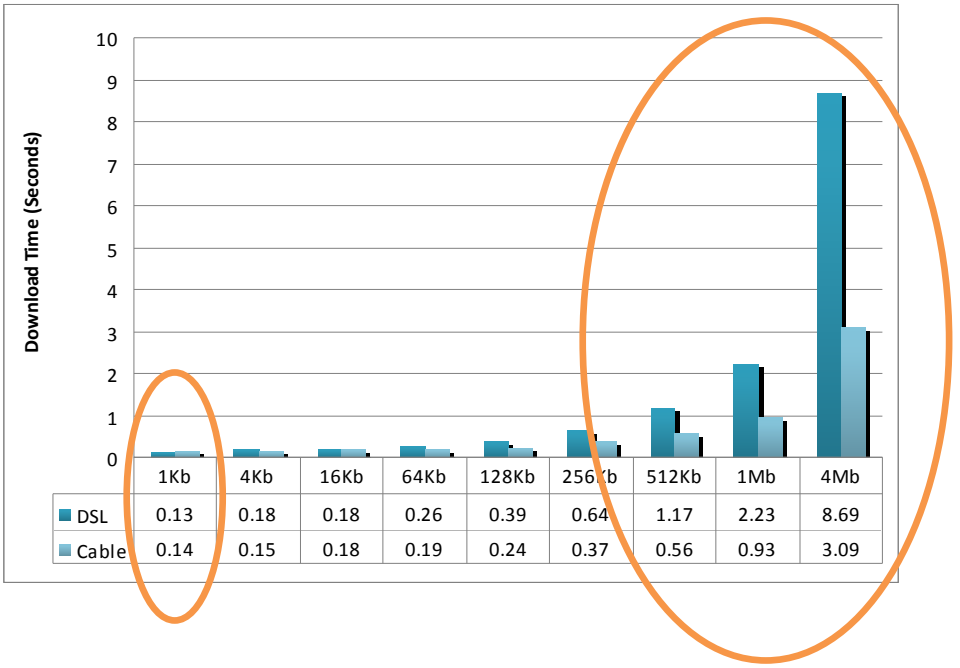
This problem of download time variability is not encountered in DSL, T1, or dialup networks, so we can conclude that the download time variability is due to the last-mile 3G carrier network. This is a problem overlooked by most users, who are often influenced by the bandwidth myth.

3.1.2 The bandwidth myth

Many people think that the most important number in overall download speed is bandwidth. This is the number that most cable and DSL providers advertise. However, bandwidth is only part of the equation.

End users access the Internet most often for browsing home pages, checking their e-mail, buying products online, or completing their banking transactions. The individual files that make up these pages are on average very small (under 64 Kb each). For these small, more transactional pages, network speed becomes much more critical than the bandwidth. For downloading larger files (those with sizes greater than 256 Kb) like Flash movies and media files, bandwidth is a major factor in overall speed.

To ensure an optimum end-user experience, both bandwidth and network speed need to be examined.



	1Kb	4Kb	16Kb	64Kb	128Kb	256Kb	512Kb	1Mb	4Mb
DSL	0.13	0.18	0.18	0.26	0.39	0.64	1.17	2.23	8.69
Cable	0.14	0.15	0.18	0.19	0.24	0.37	0.56	0.93	3.09

The above graph shows an example of the download time for files of varying sizes over both DSL and cable connections. The cable connection is 10 Mbps and the DSL connection is only 5.0 Mbps. If bandwidth were the major factor in performance, one would expect the cable provider to be twice as fast for all types of files. However, this is not the case. For a small 1 Kb file, the DSL connection was able to download the file more quickly. This indicates that

the network speed (not bandwidth) is better for this DSL network compared to cable. Even for a larger 64 Kb file, the difference between DSL and cable is not significant. The DSL file is not 2X slower, but instead is only slightly slower.

Since most Web pages are collections of files under 64 Kb, the difference between DSL and cable (or higher and lower bandwidth connections) is less significant than one would expect. There are limits, of course, and as bandwidth drops below 1.5 Mbps performance is greatly affected.

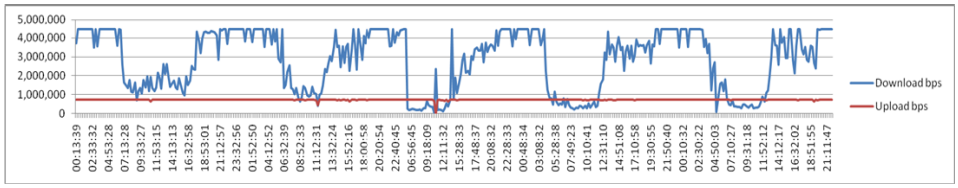
For large files, having higher bandwidth does pay off, with cable downloading files larger than 512 Kb twice as fast as DSL.

The bandwidth available to the end user depends on traffic. Understanding how files of different sizes perform on various last-mile networks monitored over a period of time is therefore useful in designing high-performing pages and applications.

3.1.3 Traffic congestion

While the core of the Internet has almost limitless bandwidth, the last mile is susceptible to the amount of traffic.

As more and more data packets flow through network pipes, congestion causes slower speeds, longer roundtrip times, and increased queuing. This situation is similar to public roads during rush hour, when too much traffic causes congestion and delays. Cable can deliver higher bandwidth than DSL. DSL, on the other hand, does not interfere with the end-user's ability to make/receive phone calls. The downside for cable is that the more people use cable, the slower the service becomes due to congestion in the last mile.

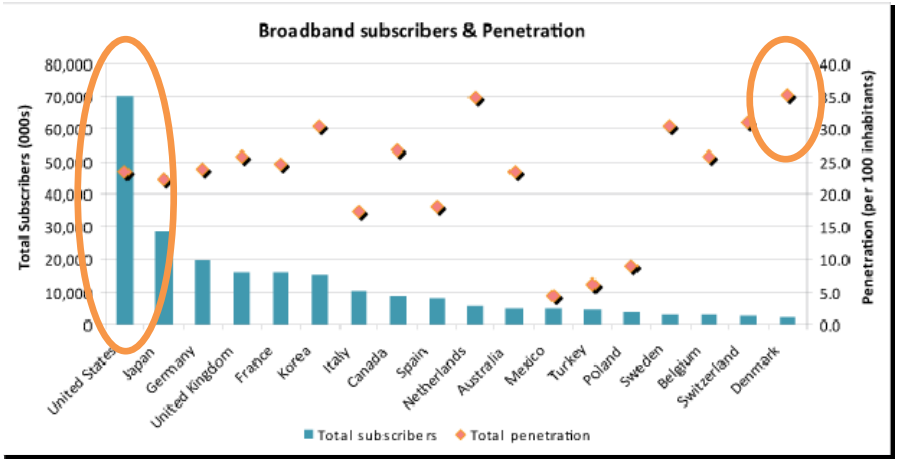


The graph above shows the effective bandwidth and how it varies throughout the day. It highlights the drop in bandwidth during congested daytime hours. Therefore, the perceived user experience will vary with the time of the day/load on the network, especially if the last mile is cable. Similarly, congestion on 3G networks in dense regions can impose similar last-mile performance degradation.

3.2 Broadband adoption trends and their impact on last-mile performance

Increased adoption of broadband technologies worldwide, such as DSL and cable, and now FTTH, holds the promise of solving these performance issues – at least those associated with bandwidth.

The graph below shows the total numbers of broadband subscribers in the top 15 countries. The graph also indicates the broadband penetration in each country.[17]



The United States leads with 69.86 million broadband subscribers, followed by Japan and Germany. However, the list of the top most-wired countries in the world is led by Denmark with 35.1% penetration. The criterion used for broadband penetration in each country is calculated as subscribers per 100 inhabitants. The United States ranks 15th in broadband penetration due to factors such as population size, geography, and broadband price, among others. As mentioned earlier, in 2007 the U.S. broadband market added 9 million household subscribers for a total penetration of 70%. This trend is expected to continue.[18]

In spite of the increase in broadband penetration, organizations need to be aware of the bandwidth challenges posed by value-added services such as video and online gaming. Significant numbers of service providers also offer flat-rate policies, which lets consumers pay a set amount for unlimited Internet access rather than pay for each page or each download. These plans encourage usage, creating additional demands on bandwidth over the last mile.

3.2.1 Broadband value-added services (VAS)

Providers have begun to offer premium services to subscribers as a way of generating additional revenue. These include video conferencing, video on demand (VoD), IP telephony, Internet Protocol TV (IPTV), music downloads, and online games. While VoD and IPTV are already well entrenched offerings with DSL providers, music downloads and online gaming are fast gaining momentum. A survey of the popularity of VAS shows that subscriptions to Internet Protocol TV services in North America will rise from 643,000 in 2006 to over 10 million in 2011, when 7.5% of North American households will have IPTV.[19]

VAS, like multiroom DVR capability and dual-mode handsets, also increases the demand for bandwidth, thus influencing last-mile performance.

The table below highlights various broadband VAS offered in different countries. Operators are currently investing heavily in new IPTV platforms and promoting their products aggressively.[20]

3.2.2 ISPs: Adjusting business models to accommodate rising bandwidth demand

Online videos viewed in the U.S. jumped 45% from last year to 12 billion in May 2008.[21] The increase in online video viewing continues to drive worldwide broadband bandwidth consumption. According to VideoNuze,[22] Internet service providers (ISPs) are deploying several different ways to address this situation. Comcast until recently has been using network management tools to block or slow certain kinds of traffic like peer-to-peer.

	Fixed Telephony		TV		Mobile
	PSTN	VoIP	DTT	IPTV	Telephony
France	Yes	Yes	Yes	Yes	Yes
Taiwan	Yes	Yes	No	Yes	Yes
Germany	Yes	Yes	Yes	Yes	Yes
Italy	Yes	Yes	Yes	Yes	No
UK	Yes	Yes	Yes	Yes	Yes
Netherlands	Yes	Yes	Yes	Yes	Yes
Australia	Yes	Yes	Yes	Yes	Yes
Japan	Yes	Yes	Yes	Yes	No
Finland	Yes	Yes	Yes	Yes	Yes
Spain	Yes	Yes	Yes	Yes	Yes

This approach is, however, very difficult to legislate and regulate.

Time Warner Cable uses a different approach by defining bandwidth caps for users for each tier of service. It limits the bandwidth consumption in each cap, similar to the cell phone model used today. The user pays according to the tier he or she subscribes for and pays extra if consumption exceeds the cap. Even though the approach is simple, it creates confusion in the minds of the consumers, since they worry about whether their bandwidth usage will exceed the quota for their service tier.

Another, more expansive approach is for the ISPs to deploy hardware and software that would enable “managed services” to be delivered at a specific quality level and at a specific price to users. Here the consumer would be buying a specific service instead of a tier. To implement this approach the ISPs partner with CDNs that guarantee certain delivery metrics. These CDN guarantees cannot, however, reach into the “last mile” that the ISP’s network serves. The use of managed services would also require fundamental changes in how the companies currently work together. With the increase in bandwidth-intensive content, however, ISPs will need to use some strategy to ensure better last-mile performance.

4. Measuring and Monitoring the Last-Mile Performance

A best-in-class solution should provide:

- Actionable performance data for rapid problem resolution.
- Measurement of connectivity issues from first mile to last mile.
- Testing and monitoring across different geographies.
- Identification of the cause of the problem by comparing performance over last-mile access types such as DSL, 3G, dialup, and cable to that of T1/T3 connections.
- Drill-down information to the last mile to view DNS, CDN, SSL, first-byte download, content download, and other details that could be causing problems.

Because of bandwidth-intensive industry trends and developments in the last mile, understanding customers' online experience, down to the smallest detail, has become critical for companies to ensure business success. While Web site responsiveness is the key to a superior user experience, location, time of day, access mechanisms, and tariff structure influence the end-user experience. Web operations teams need tools that will alert them in real time when their Web site performance falls below acceptable thresholds. Therefore, measuring and monitoring the end-user experience in a detailed manner is the key to ensuring a uniform Web experience on the last mile.

Measuring and monitoring Web site and Web applications on a timely, incremental basis throughout the day using agent-based monitoring in realistic yet consistent scenarios continues to be the most popular and viable form of monitoring.

It is essential that this monitoring be performed from the end-user's perspective, demonstrating how online business performs at the application, transaction, and infrastructure levels, in real time.

Given the issues with last-mile performance discussed in this report, it is also imperative to use a global measurement network, with specially configured measurement computers at multiple locations in various geographies, both in metropolitan and sub-metropolitan areas. And staying ahead in a hyper-competitive market requires insights that can benchmark an organization's Web performance against that of competitors – from the first mile all the way to the last.

Conclusion

Web 2.0 has helped transition the Internet to a platform for business and communication. Applications like online RIAs, Flash videos, mashups, and VoD are now commonplace, but their performance continues to depend on the type of last-mile access and to vary drastically. A rewarding end-user experience can be ensured only when the performance of the Web site and Web applications is monitored globally from the end-user perspective.

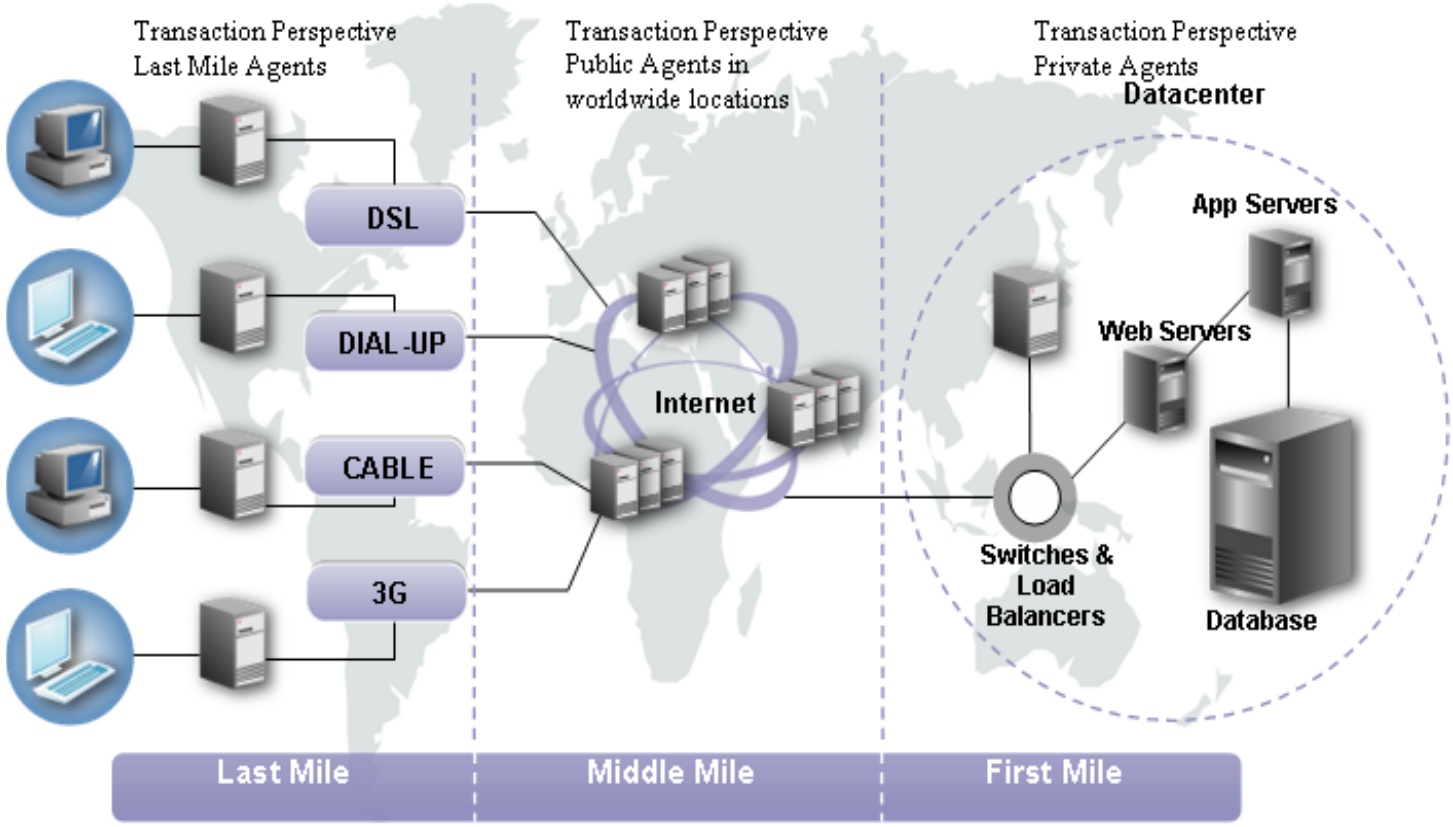
Performance characteristics vary across geographic locations, and Internet traffic congestion and last-mile latency can degrade Web site performance significantly. However, reliable performance monitoring and traffic analysis across geographically spread locations can provide vital information to ensure a site's success. A best-in-class solution provides a streamlined process to measure and monitor Web sites and mission-critical Web applications across the globe, while providing real actionable insight into the end-user experience.

With the last mile under careful scrutiny, service providers and companies can have a considerable business impact on customer satisfaction and, ultimately, realize enterprise-wide success.

About Keynote

Keynote is the leading provider of on-demand test and measurement solutions for continuously improving the online experience. We enable companies to know precisely how their Web sites, content, and applications will perform on actual browsers, networks, and mobile devices long before their customers and business are impacted.

Among our many offerings, Transaction Perspective™ for Last Mile provides comprehensive performance results and superior measurement capabilities for online business transactions from the end–user perspective. Keynote's global measurement network of 2,500 measurement computers in more than 240 locations worldwide is the largest and most accurate real-time measurement, monitoring, and testing infrastructure in the world. It gives our customers a true portrayal of what users are experiencing on their end of a Web browser or mobile device.



Transaction Perspective Last Mile Agents use a standard Internet Explorer browser to actively generate synthetic transactions from representative locations worldwide using dedicated measurement agents over various access types.

Key benefits

Transactions Perspective™ Last Mile provides:

- Competitive benchmarking
- Accurate (real browser) last-mile measurements
- Fast diagnosis on the basis of actionable reports

• On-demand, hassle-free, and reliable test and measurement infrastructure

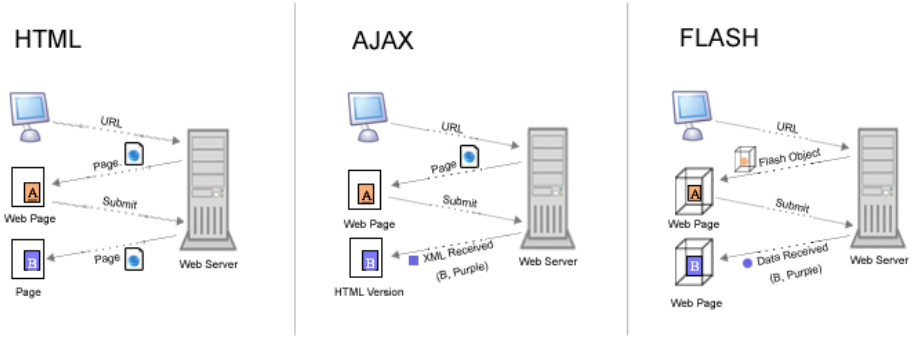
• Alerts about errors through regular e-mails and messages

• In-depth last-mile measurements to view DNS, CDN, SSL, first-byte download, content download, and other details that cause performance related problems

• Support for all access types, including DSL, 3G, cable, and dialup

Appendix 1

Some basics – HTML, AJAX, and Flash



With pure HTML, the entire page is reloaded on a transaction. With AJAX, only the relevant portion of the page gets refreshed with a much smaller XML stream. However, with Flash, the initial download is usually much heavier, while subsequent transactions are the same size as the AJAX XML transaction or smaller.

Footer

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