OTT Video: A Revenue Opportunity for Mobile Operators
## OTT Video
### A Revenue Opportunity for Mobile Operators

![Table of Contents](image)

- **Executive Summary** ........................................... 3
- **Faster Networks Drive Higher Video Consumption** .................. 3
  - Unmanaged Video Traffic Will Consume
  - Higher Proportions of Faster Networks ............................. 3
- **Streaming Protocols Consume Bandwidth**
  - Quickly with Higher-Resolution Videos ............................ 4
- **Operator Tariffs Can Impact Adoption of Video** .................. 5
  - Quota Plans May Constrain Video Adoption ...................... 6
  - Speed-Based Tariffs Should be Conducive to Video Adoption .... 7
  - Unlimited Plans Will Drive More Video Adoption ............... 8
- **Video Controls Implemented at Launch Provide a Consistent Subscriber Experience throughout the 4G/LTE Network’s Life** ................. 8
  - Pre-empting the 4G/LTE Capacity Crunch .......................... 9
  - QoE-Based Services ............................................. 10
  - Addressing the Impact of Transient Congestion and Traffic Behavior .......... 11
  - Upselling of Services ........................................... 11
- **Smart Capacity Turns Video into a Revenue Opportunity** ........ 13
  - Summary .......................................................... 14
  - Improving the User Experience under Network Load ............. 15
  - User Experience Indexing for Unique Insight and Control .... 15
  - Measuring Video and Web Quality Metrics in Real Time ........ 16
- **Service Differentiation: Smart Capacity in a Policy-Enabled Architecture** .... 16
  - Triggering Service Actions through Optimization and UXI ....... 17
  - Policy Actions for Premium and Basic Subscribers ................ 18
- **Appendix** ..................................................... 19
Executive Summary
As mobile operators launch Long Term Evolution (LTE) and other 4G networks, they can take advantage of the growing popularity of over-the-top (OTT) video and the new mobile devices that support it.

Citrix ByteMobile Smart Capacity™ solutions can serve as the video control point in 4G/LTE networks, enabling operators to deliver QoE-based services and to turn the rapid growth of video adoption into a major revenue opportunity.

Faster Networks Drive Higher Video Consumption
Industry research analysts, systems vendors and network planners all see evidence that mobile data volume will grow dramatically in the coming years - up to seven times from the end of 2011 to 2014 (Federal Communications Commission, 2010). Within mobile data, video is expected to contribute the single largest portion of traffic, at over 70% by 2016 (Cisco Visual Networking Index (VNI) Global Mobile Data Traffic Forecast Update, February 2012) - and thus become a critical driver of traffic growth.

Unmanaged Video Traffic Will Consume Higher Proportions of Faster Networks
Citrix conducted research across several 3G and 4G networks in the U.S., Europe and Asia, with average network download rates that differed measurably. The company tracked the average video download speed, the percentage of total traffic represented by video, and the percentage of mobile subscribers that actively viewed online video. The key findings were that:

• As the average video download bit rate increased due to network speed and bandwidth availability, the respective percentages of both video traffic and subscribers that viewed video grew precipitously

• A relatively small increase in the percentage of subscribers watching video can have a dramatic impact on total traffic volume

The FCC has reported a comparable trend in wireline broadband networks for overall user adoption of the Internet. Its study concluded that the faster the network, the more time subscribers spent online (Federal Communications Commission, 2009). The corollary in mobile networks is: the faster the network, the higher the adoption of video.
Data from an anonymous cross-section of 3G operators indicates that networks with higher average video bit rates carry a higher percentage of video content in their networks and support a higher percentage of mobile subscribers viewing videos. Source: Citrix ByteMobile.

This fact has broad implications for mobile operators. Network technology upgrades such as HSPA+, LTE and LTE-Advanced will drive more video through the network, creating a ‘capacity continuum.’ Left unmanaged, video traffic will consume progressively larger proportions of data traffic in progressively faster mobile networks.

What measures can operators take to intelligently manage video traffic? Can these measures evolve into a broader strategy that targets mobile video as a significant business in its own right?

This white paper addresses these questions from the perspective of Citrix experience in helping operators manage video traffic, improve QoE for their subscribers, and differentiate their service plans based on subscriber usage. The objective is to fully monetize the assets inherent in 4G/LTE networks, based on the unprecedented volume and mix of multimedia traffic that they will both drive and support.

Streaming Protocols Consume Bandwidth Quickly with Higher-Resolution Videos

Video content providers such as Netflix, Hulu, Apple, and others have converged on protocols classified as adaptive bit rate (ABR) streaming for premium content. There exist several implementations of these protocols from Adobe, Apple, and Microsoft, and they all share a common approach. Effectively, they adapt in real time to network throughput and device CPU capabilities by dynamically increasing or decreasing the resolution of the video. Different versions of the same video are stored on content servers according to resolution levels and encoding types. For
example, a movie or a TV news report would have at least five versions based on bit rate – two low-definition, one standard-definition, and two high-definition (HD) videos – 720p and 1080p. As network conditions change, the content server switches among the different bit-rate versions to deliver the highest bit rate version that the available bandwidth will accommodate.

A key behavior of ABR streaming protocols is that they attempt to consume as much of the available network capacity as the content server can utilize and deliver the highest quality that the current network connection can support. For example, if the network can support throughput of 3.5 Mbps, then an HD video stream is sent to the subscriber – regardless of other, competing demands on bandwidth.

As operators roll out LTE and other very fast 4G networks:

- Premium content videos using ABR streaming protocols will consume a sizable portion of the available channel to the subscriber – regardless of device capabilities or policies related to the subscriber’s data plan
- As a result, where 3G networks support video resolutions that are predominantly in the low-definition to standard-definition range, 4G/LTE networks regularly stream HD videos requiring 3.5 Mbps per stream

With subscriber behavior shifting to premium content in 4G/LTE networks, and streaming protocols sending the highest-quality video across a link, video traffic expands to fill the network capacity available for it. Mobile operators expecting the capacity of their 4G/LTE networks to exceed the growth requirements of video may soon discover that their pipes are loaded with HD content.

Devices such as Apple’s iPad and the latest Android devices all support HD video. Unless the delivery of HD video is controlled, operators could waste network capacity on high-bandwidth video streams that are not supported by their subscribers’ devices.

**Operator Tariffs Can Impact Adoption of Video**

Tariffs have a direct bearing on the adoption of video by mobile subscribers. Most network operators develop rate plans within an overall business model designed to strengthen their competitiveness in the mobile data market. The rate plans – in conjunction with access to special mobile devices and the performance of the network – are key criteria for competitive differentiation relative to other operators serving the same or similar markets. Tariffs for 3G networks are simple in structure, with most postpaid plans based on either a monthly quota or unlimited data volume. Some plans bundle access to services such as YouTube and Facebook for a flat fee.

3G network tariff structures are migrating to 4G/LTE, based on a survey of operators conducted by Citrix. The 4G/LTE tariffs can be grouped broadly into the following categories:
• **Quota-based** – Subscribers purchase a monthly quota of data volume, beyond which access to the network is throttled until the beginning of the next billing period. A breach of quota typically results in the application of special charges.

• **Speed-based** – Subscribers are offered different levels of network speed, from which they can purchase a monthly plan based on their selection. A quota may or may not be built into the plan. Some speed-based plans enforce fair use policies for the top percentile of subscribers.

• **Unlimited with fair use policy** – Subscribers are offered unlimited data volume with unspecified bandwidth. The operator targets heavy users – say, the top 2% by volume – for the application of fair use policies. When subscribers reach the fair use threshold, their access to the network is throttled down to a low but functional bit rate. For some networks, this bit rate provides sufficient bandwidth for web browsing but impacts the performance of standard-definition videos.

• **Unlimited without fair use policy** – The operator provides an unlimited data plan but does not impose a fair use parameter. Instead, network performance for all subscribers is capped at an upper bit rate such as 1 Mbps.

• **New models (e.g., application-based)** – These plans are emerging in different forms, with operators targeting specific subscriber demographics with bundled services providing access to certain applications.

**Quota Plans May Constrain Video Adoption**

Real-world experience indicates that quota-based restrictions tend to conflict with user behavior as consumption of high-quality video becomes increasingly popular. This poses a problem for operators attempting to meet customer expectations of value from innovative mobile devices on LTE networks.

For many subscribers, data volume is a metric that is neither easy to understand nor comparable to their own usage patterns. For example, how can the average consumer with a mobile device understand that watching a 30-minute video generates approximately 100 times more data volume than a 30-minute web browsing session? Or that the same 30-minute video in high definition consumes more than half a gigabit of data? As The Wall Street Journal reported, a subscriber can breach a monthly quota plan after watching just two hours of video (“Video Speed Trap Lurks in New iPad: Users Find the Superfast 4G Link Carries a Big Cost: Churning Through Data Limits in Mere Hours” – March 21, 2012).

For quota-based plans to work in the 4G/LTE world of premium video content, mobile network operators need to raise quota levels to meet customer expectations. Otherwise, a tariff mismatch between subscriber behavior and allowable data volume will exert pressure on the mobile video ecosystem. Poorly designed quotas will constrain the uptake of mobile video. This in turn will limit operators’ ability to capitalize on the video value chain.
Speed-Based Tariffs Should be Conducive to Video Adoption

In the case of speed-based plans, the majority of subscribers are limited in their ability to identify the correlation between network speed and a usable data service. For example, one of the early LTE network operators in Europe offered an entry-level plan with speeds of up to 7 Mbps and a more advanced package with speeds of up to 15 Mbps. Other than data speed, the subscriber has no way to measure the quality or value of the service delivered. Another LTE operator in the U.S. advertised an average speed — setting the expectation that the faster the service, the better the plan. Broadband wireline services have also created a precedent for the subscriber perception of speed as a service differentiator.

Many subscribers equate speed with an expectation of what they can do on a 4G/LTE network with their mobile devices, while others determine the speed that they need for their everyday use. For speed to become a well-understood factor in tariff amounts, operators need to educate their subscribers and create easy-to-comprehend service levels. Since the tiering of services circumvents today’s volume limits, this type of tariff should be conducive to subscriber adoption of video.

Tariffs for 4G/LTE service are based on a data volume quota that is reset monthly, on an unlimited plan, or on speed. Subscribers are challenged to identify how much data or network bandwidth they really need for their everyday applications, making customer education a critical imperative for operators.
Unlimited Plans Will Drive More Video Adoption

Unlimited plans are a relatively new 4G/LTE tariff strategy which enables operators to differentiate their networks from others serving the same market. The concept of unlimited data is very easy for subscribers to understand, based on their experience with 3G services. The potential challenge for operators is subscriber adoption of video even above the rates projected for these types of plans. Operators need to dimension their networks appropriately or apply intelligent controls to address spikes in mobile data traffic driven by video. A North American tier-2 operator recently launched LTE services with an unlimited plan for all of its subscribers. The operator has managed the expected surge in video traffic by imposing a speed limit which is sufficient for subscribers to view standard-definition video.

Emerging plans that target specific traffic types (e.g., video content from partner sites) – which are currently offered by certain tier-2 and tier-3 operators – may become popular as more subscribers adopt them.

Another consideration in implementing 4G/LTE services is that many subscribers will oscillate, via handovers, between 3G and 4G access networks, depending on where they are and the available 4G coverage in that area. How does the operator align usage volumes between the two networks? Does the operator provide two billing ‘buckets’ for 3G and 4G data volumes? Or discount usage on the 3G network as it adds that volume to a combined bucket?

Video Controls Implemented at Launch Provide a Consistent Subscriber Experience throughout the 4G/LTE Network’s Life

It stands to reason that 4G/LTE operators will face the same problem that they experienced with 3G over the useful life of the network – that is, as more subscribers adopt the new services, the QoE for all subscribers will be degraded. The lesson learned in 3G was that early adopters are rewarded with an excellent experience because the network serves a limited number of subscribers. As the network ramp ups with subscribers migrating from 3G services, the quality of that experience will gradually and uniformly decline for all users – regardless of service plan. This is precisely the cycle that characterized the maturation process for 3G networks.

As 3G networks achieved higher utilization rates, subscribers had degraded experiences depending on time of day and location within their service area. 4G/LTE networks will have the same issue, resulting in a ‘capacity crunch’ as more subscribers migrate to the new services.
When launched initially, 4G/LTE networks are lightly used, leading to excellent QoE for all subscribers. As more subscribers migrate to these new services, the average QoE is degraded equally for everyone. After a few years, all subscribers experience degradation caused by network congestion and busy-hour traffic.

**Pre-empting the 4G/LTE Capacity Crunch**

Prior to launching 4G/LTE services, operators can pre-empt the capacity crunch by implementing intelligent controls that differentiate services according to key criteria that drive the network’s business model:

- **Device type** – higher-end devices versus lower-end devices
- **User type** – subscribers willing to pay a premium price for a premium service versus those satisfied with a basic service at a low price
- **Application type** – applications that require priority handling versus those that do not

As more subscribers migrate to the 4G/LTE network, the operator can apply different degrees of policy enforcement to address congestion and network hot spots – based on type of device or willingness to pay for a premium service. During periods of congestion, subscribers that pay for a better experience, use a higher-end device or both can enjoy a premium experience, while those that pay for a basic experience or lower-end device will have their service subordinated in terms of quality and priority. This adjustment is necessary to ensure that available network resources support premium subscribers, with minimal to no perceptible degradation for all other subscribers.

Would service differentiation based on QoE and willingness to pay appeal to subscribers? Consumers are already well versed in the reality that higher quality costs more. For example, they are willing to pay more for:
• Blu-ray discs versus standard DVDs
• HD TV sets versus traditional standard-definition TVs
• HD TV channel packages versus standard-definition TV channel packages

Certain operators offer differentiated services that are defined by Gold, Silver and Bronze data plans. A tier-1 operator with such plans has provided Citrix with feedback to the effect that its subscribers can discern service levels based on QoE and can decide which plan delivers the best value for their mobile data needs.

QoE-Based Services

What defines 'quality of experience' for a mobile data consumer? The answer lies in the pervasive observation that subscribers’ perceptions map directly to the performance of applications on their mobile devices. Key metrics for application performance include the following:

• Video image quality and playback smoothness
• Speed of web page downloads
• Responsiveness of smartphone applications – e.g., how quickly does Google Maps render map images?

Other performance benchmarks include responsiveness of email and file transfer speeds.

It is absolutely critical that before developing a QoE-based service differentiation model, the operator understands how to actually measure the quality of experience from the subscriber’s viewpoint – i.e., video quality and smoothness, web page download speed and app responsiveness. These measurements should be taken for each subscriber, with the resulting data compiled to show findings by device type, user type, application type, and other important criteria.

With the ability to measure QoE comes the need for a common approach to enforce or influence the experience being delivered relative to applicable policies and prevailing network conditions. For example, by influencing the subscriber’s ability to access higher-quality video, the operator is able to create specific tariff plans that more closely reflect the conventional 'you get what you pay for' model discussed in the previous section:

• Premium subscribers pay for and enjoy HD videos streamed to their higher-end devices
• Others with a basic plan or lower-end device are restricted to standard-definition or low-definition videos
Addressing the Impact of Transient Congestion and Traffic Behavior

However, enforcement of QoE policies is not enough. Mobile networks exhibit a number of key differences from their wireline counterparts. The most obvious of these is 'mobility' – transient congestion is much more likely to occur in mobile networks. The ability to manage constantly changing and sometimes unpredictable traffic behavior in a holistic way is critical to providing differentiated services based on QoE. Managing the user experience also requires the ability to apply controls which enable operators to deliver the best possible QoE to higher-value subscribers and devices during periods of congestion or other transient network conditions. For example, if two subscribers are using a congested part of the network at a certain point in time, the subscriber with the higher-value service plan or device would receive QoE priority over the subscriber with the lower-value service plan or device. This may mean that the lower-value subscriber’s experience is degraded in order to ensure that sufficient bandwidth is available to maintain the higher-value subscriber’s quality.

This diagram summarizes actions that operators would take for premium and basic users through varying network conditions. Basic users – those with a basic data plan or lower-end device – would be prompted for an upgrade for a premium experience.

Upselling of Services

With the ability to differentiate QoE according to service plan or device type, operators require the option to 'upsell' subscribers a higher level of service – either permanently with a new plan or temporarily for a specified period of time. This option appeals to a certain percentage of subscribers seeking the premium experience at that particular moment and another, smaller percentage of subscribers seeking the premium experience for all content.
In order to upsell a subscriber, the operator needs a mechanism to communicate the options available and their respective advantages. For example, a subscriber with a basic plan or lower-end device has limits on video service which allow standard-definition but not HD quality. If that subscriber attempts to gain access to HD video, then the operator has a potential upsell opportunity. The operator can capitalize on that opportunity with an intelligent notification to the subscriber which is inserted in the video content itself:

*We noticed that you are trying to access higher-definition video content, which is restricted in your current plan. Would you like to change your plan?*

Alternatively, the operator can offer the subscriber access to HD videos through a temporary quality boost, which gives the subscriber a ‘taste’ of the premium experience on his or her device. As an added incentive to upgrade, the operator can offer the subscriber a set number of quality boost credits per billing period.

Implementing service plans based on QoE in no way diminishes the need for speed- or quota-based plans. In fact, QoE-based services allow for a richer set of plans that segment the subscriber differentiated services for the video and web experience.

As part of these services operators can give subscribers control over how they consume their quotas. This control could take the form of a ‘personalization’ app or web interface through which the customer chooses among options for higher-quality service. The app or interface would show the customer how the selected personalization options would impact usage for the month. It would also answer frequently asked questions – for example, is the subscriber watching more video with access to HD? Is the current service meeting the subscriber’s expectations in terms of the monthly charge? Is the subscriber willing to upgrade to a higher-quality service plan to match the desired experience level?
Operator controls available through a smartphone app enables subscribers to personalize their video and web service and understand its impact on their mobile data consumption.

Using mobile data traffic analytics, the operator can determine individual subscriber preferences for video quality and propensity to pay for higher-quality video. Insights of this nature are essential to service modeling efforts which include an assessment of the market appetite for differentiated data plans based on QoE.

**Smart Capacity Turns Video into a Revenue Opportunity**

Citrix ByteMobile solutions have been helping operators manage the growth of data traffic in their mobile networks for 13 years. The company’s Smart Capacity™ solutions have enabled operators to:

- Enhance the user experience by improving application performance, particularly under network load, by speeding up web browsing and making video playback more smooth
- Increase overall network efficiency through elimination of wasted and inefficient traffic and optimization of the traffic most critical to both operators and subscribers – web and video

The adoption of video services by mobile subscribers has made it imperative for operators to maintain the performance of their network while sustaining data revenue growth and profitability in the face of rapidly escalating traffic. Anticipating the impact of mobile video, Citrix launched its first suite of video control applications in 2009. Today, more than 70 operators worldwide are under contract for these solutions, while more than 50 of them have live deployments in their networks.
With sizable investments in 4G/LTE technology planned for the radio access network (RAN) and mobile packet core, operators understand the need to deploy the capacity of their new networks most effectively. Specifically, they need to generate strong revenue growth across their entire subscriber base – in parallel with traffic growth and driven by exceptional QoE. As a result, the ability to control video traffic intelligently and dynamically is becoming even more of a critical requirement for operators’ infrastructure strategy. The alternative is to rely on capacity upgrades to accommodate traffic growth while using tariffs to control subscriber behavior and manage video consumption.

QoE-based service differentiation is a new strategy that is friendly to subscribers, to the mobile video ecosystem and to the carrier’s operating and capital budgets. This strategy segments subscribers based on data plan or device purchased and focuses on the delivery of levels of experience that correspond directly to monthly rates paid (e.g., a premium experience at a premium rate). In the near term, operators can view service differentiation as a cost-effective way to manage the existing 3G capacity crunch while preparing to deploy their 4G/LTE networks. This will ensure that the proper controls are in place across all broadband network access types. ByteMobile Smart Capacity solutions enable operators to deliver QoE-based services today through effective control of both web and video traffic.

**Summary**

Operators are well aware of the impact of video on their mobile networks today. They can now deploy smarter techniques to control the performance of their capacity upgrades and manage video and web traffic at a granular level for different types of subscribers and devices on both 3G and 4G/LTE networks. While the growth of video may be perceived as a network management challenge, the ability to holistically control and monetize escalating video traffic is a business opportunity leading to stronger data revenue growth and profitability. QoE-based service differentiation provides operators with viable ways to both meet the challenge and capitalize on the opportunity.

Citrix ByteMobile Smart Capacity solutions enable operators to deliver differentiated service plans to their subscribers, based on quality, device and willingness to pay. These solutions include tools that regulate subscriber consumption of data with more marketable service policies. Video is driving mobile data growth, and video quality is driving subscriber perceptions of the user experience. From their experience with numerous other consumer transactions, mobile data subscribers are conditioned to the fact that higher quality costs more, while lower quality costs less. Service differentiation based on QoE leverages these factors, offering new monetization opportunities that will become critical for operators of 4G/LTE networks moving unprecedented and currently unpredictable volumes of data.
Improving the User Experience under Network Load

Smart Capacity solutions employ optimization at the TCP and HTTP layers, as well as video pacing and quality-based compression of video and web images. These solutions solve the problem of delivering a video formatted for a large screen to a mobile device with inappropriate screen size and resolution. During periods of network congestion, Smart Capacity solutions can increase compression levels for subscribers in order to ensure smoother video playback. The same controls can be applied for policy enforcement to reduce data volume during roaming and alleviate subscriber ‘bill shock’, or in lower-speed networks which are unable to support the resolution of the media requested by the subscriber.

Video optimization views media holistically and intelligently determines which video control techniques to apply based on user, network or operator policies; device types; and network conditions. For a complete description of ByteMobile video optimization capabilities, please refer to the Appendix.

In addition to optimization, the ability to cache popular content is becoming increasingly important to the control of video traffic in QoE-based service differentiation. Videos in the majority of delivery formats can be cached, which provides several benefits (see Appendix). By intelligently combining optimization, caching and other elements, Citrix ByteMobile gives operators a single point of control to manage video traffic within the evolving mobile network.

User Experience Indexing for Unique Insight and Control

The ability to measure QoE – from the individual subscriber’s perspective – has significant strategic and operational value for operators. For example, they can adjust subscriber sessions dynamically to manage current and/or changing user experience conditions, determine compliance with service-level agreements, and understand the impact of infrastructure investments on the performance of the mobile network.

Content intelligence inherent in Citrix ByteMobile’s Smart Capacity solutions includes a User Experience Index (UXI) for video sessions, web sessions or app performance. The UXI provides a binary indicator of QoE.
Measuring Video and Web Quality Metrics in Real Time

ByteMobile Smart Capacity solutions actively monitor, in real time, the actual user experience being delivered to each data subscriber on the mobile network. The User Experience Index (UXI), for which Citrix ByteMobile has a patent pending, offers operators advanced insight into the quality of their mobile data service as individual subscribers perceive it. The principal metric is a binary value that differentiates between positive and negative experiences for multimedia content, resulting in a granular profile for each subscriber session.

ByteMobile UXI gives operators real-time intelligence for the selective application of optimization techniques. By combining UXI metrics with powerful algorithms for predicting congestion, Smart Capacity solutions help operators decide when they should employ controls to support the QoE required for any given subscriber.

The UXI also provides operators with an important analytics tool for use in customer retention, customer service and upselling initiatives. Feeding UXI scores that aggregate individual video and web sessions into customer relationship management (CRM) systems enables operators to proactively retain subscribers and respond to their queries, while making informed, tangible predictions of churn related to poor QoE.

Service Differentiation: Smart Capacity in a Policy-Enabled Architecture

ByteMobile Smart Capacity platforms serve as a powerful video policy enforcement function in a Policy Control and Charging (PCC) architecture. By combining the intelligence from an external Policy and Charging Rules Function (PCRF) – for example, policy entitlements, service status and detailed cell location information – operators can apply real-time adaptive controls to enforce each subscriber’s service plan and manage network traffic spikes in an orderly way.

The PCRF enables adaptive controls to be applied in collaboration with several other points of policy enforcement in the PCC ecosystem. This collaboration focuses on the sharing of information among critical network elements involved in the creation and management of mobile data services.

An example of PCRF-controlled collaboration would be the handling of a subscriber breaching quota. A GGSN (Gateway GPRS Support Node) or PGW (Packet Data Gateway) would measure the subscriber’s data volume for quota compliance, while a Citrix Bytemobile Smart Capacity platform would control all video sessions and push a web notification when the subscriber exceeded his or her volume cap.
**Triggering Service Actions through Optimization and UXI**

Citrix ByteMobile has defined a set of policy control actions which trigger video and web optimization as a result of UXI measurements. These actions can be included in operators’ policy enforcement plans for 3G and 4G/LTE services (see diagram below). The purpose is to differentiate mobile data experiences by device type (laptops, smartphones, tablets) and by premium or basic services within each device type. Operators can use UXI-driven policy controls differently to meet specific objectives for their own services.

Policy rules trigger Smart Capacity applications to enforce service policies for laptop, tablet and smartphone users, which are grouped as premium or basic.

The principles underlying these policy controls are as follows:

- Subscribers are segmented according to the quality of service that they need and are willing to fund
- Subscribers who require and are willing to pay for the highest level of quality receive premium service, while those satisfied with a lower level of quality receive basic service
- Optimization is applied to the traffic of basic subscribers in order to create bandwidth headroom for the traffic of premium subscribers
- Optimization is applied to the traffic of premium subscribers only when necessary – mainly during periods of congestion or when link connections are weak
Policy Actions for Premium and Basic Subscribers

Subscriber plan types – premium and basic – are determined within the operator’s policy domain. For premium subscribers on laptops and tablets, operators may choose to apply video controls only when network conditions and the UXI indicate that QoE can be improved.

In contrast, basic subscribers on laptops and tablets would be subject to always-on video and web image compression at medium quality under both normal and congested network conditions. During periods of high capacity utilization, operators may choose not to apply congestion control that would drive a better user experience. Instead, they may opt to further degrade video and web quality in order to accommodate the congestion and ensure minimal to no impact on the QoE of premium subscribers.

For smaller devices such as smartphones, policy controls may dictate that basic subscribers default to low video and web image quality in keeping with their plan’s service provision or the limits of their devices. However, their videos would still be optimized during periods of network congestion.

In contrast, video and web optimization would be applied to premium subscribers on smartphones in response to congestion – and as determined by UXI metrics – in order to maintain high QoE for all sessions. In the majority of cases, video optimization would be set for high quality, making video appear visually lossless to the subscriber.

The ability for operators to decrease video resolution on devices with limited capabilities improves network efficiency by reducing or eliminating wasted data that does not contribute to QoE. This is an important consideration in managing traffic growth relative to the current and projected penetration of smartphones worldwide.
### Appendix

#### Guide to Video Control Capabilities of Citrix ByteMobile's Smart Capacity solutions

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<th>Capability</th>
<th>Description</th>
<th>Video Type</th>
<th>Compression</th>
<th>Impact</th>
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| Just-in-Time (JIT) Delivery | Regulates the delivery of video to the device at a pace only slightly above the video bit rate to ensure smooth playback | Progressive-download videos (used by most websites)                        | No          | ▪ Eliminates wasted data by ensuring the device downloads only what the subscriber views rather than the entire video (on average, most users watch only a portion of the total video)  
▪ Effective congestion avoidance properties |
| Quality-Aware Transcoding (QAT) | Determines video quality and applies to content being delivered through transcoding / transrating techniques | Progressive-download videos and RTMP streaming videos                     | Yes – manages the codec, the container and the actual content  | ▪ Reduces the total amount of data required to transfer a video by removing unnecessary frames and content – which is important for matching device capabilities to content source formats  
▪ Effective congestion avoidance properties |
| Dynamic Bandwidth Shaping (DBS) | A dynamic mode of QAT that reacts to real-time network conditions and increases compression to ensure smoother playback | Progressive-download videos and RTMP streaming videos                     | Yes – provides the capabilities of QAT progressively  | ▪ Reacts to real-time network congestion by dynamically reducing throughput requirements to deliver video smoothly  
▪ Effective congestion management properties |
| Streaming Policy Control (SPC) | Manages the play rate at which streaming protocols (including audio) are delivered to the device  | ▪ HTTP-based adaptive bit rate videos (Apple Live Streaming, Microsoft Smooth Streaming)  
▪ RTMP, RTMPE streaming videos  
▪ Progressive-download videos | No          | Gives operators control of streaming protocols that would otherwise use all available network throughput to drive delivery of the highest possible quality  
▪ Mitigates the impact of streaming video on high-speed networks, enabling operators to control how it is delivered to the device |
| Caching                  | Caches up to 60% of video data volume for popular content requested repeatedly by multiple subscribers, accelerating start time and reducing stalling for video playback. | ▪ HTTP-based adaptive bit rate videos (Apple Live Streaming, Microsoft Smooth Streaming)  
▪ RTMP, RTMPE streaming videos  
▪ Progressive-download videos | Yes – with QAT or DBS | ▪ Improves the user experience through the mitigation of external congestion factors  
▪ Reduces amounts of video traffic from the Internet  
▪ Improves efficiency of video optimization through the pre-optimization of content within the cache |
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About Citrix ByteMobile
Citrix ByteMobile Smart Capacity™ enables mobile operators to dynamically improve mobile subscriber quality of experience (QoE), increase available network capacity and better monetize over-the-top content. The T-Series Adaptive Traffic Management System is the industry’s only fully integrated traffic management system – delivering adaptive web and video optimization, DPI, caching, load balancing, analytics and policy control in an integrated, centrally managed architecture for efficient and streamlined deployment of multi-Tbps-scale traffic management across the mobile network.

About Citrix
Citrix (NASDAQ:CTXS) is the cloud company that enables mobile workstyles—empowering people to work and collaborate from anywhere, easily and securely. With market-leading solutions for mobility, desktop virtualization, cloud networking, cloud platforms, collaboration and data sharing, Citrix helps organizations achieve the speed and agility necessary to succeed in a mobile and dynamic world. Citrix products are in use at more than 260,000 organizations and by over 100 million users globally. Annual revenue in 2012 was $2.59 billion. Learn more at www.citrix.com.

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