Mobile Video Explosion

WHITE PAPER

Challenges and Solutions for Operators

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Mobile Video Traffic Volume Continues to Skyrocket

The consumer's desire to consume digital media at any location at any time seems insatiable. Fueling this growth is the increased capacity and reduced pricing of mobile devices and their associated data plans.

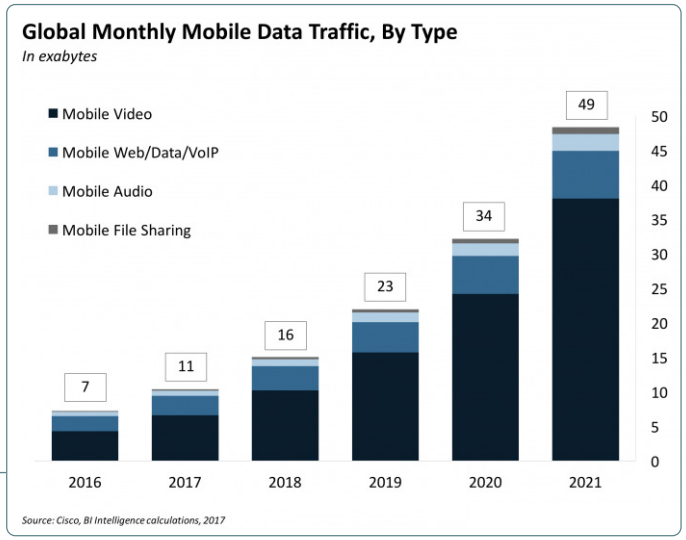
The attraction of technology and media is so strong that the US Bureau of Labor Statistics[1] has found that the average American spends more time using technology and consuming media than working or sleeping.

Among all types of digital media, video is most popular. According to the Cisco annual VNI[2] forecast, worldwide consumption of mobile video will grow nearly ninefold from 2016 to 2021, and will account for 78% of all mobile traffic by the end of 2021, up from 60% in 2016. From 2016 to the end of 2021, while global mobile data traffic will increase 700%, mobile video consumption will grow even more at 870%.

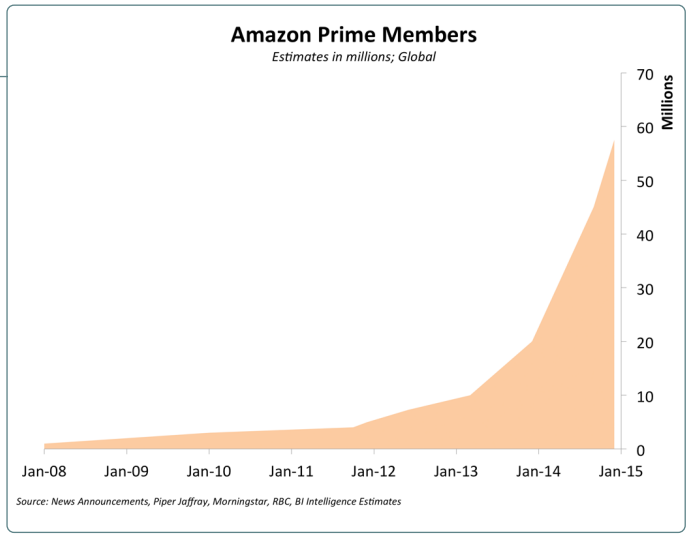
Cisco predicts, by 2019, 80% of all Internet traffic will be video. The dramatic increase will be driven by the increased popularity of over-the-top (OTT) video delivery.

Video and traditional TV consumption has changed dramatically in recent years. Gone are the days of limited channels, with viewers at the mercy of program schedules. OTT video service providers such as YouTube, Netflix, and Amazon have disrupted the old model with a new and personalized "on-demand" video service.

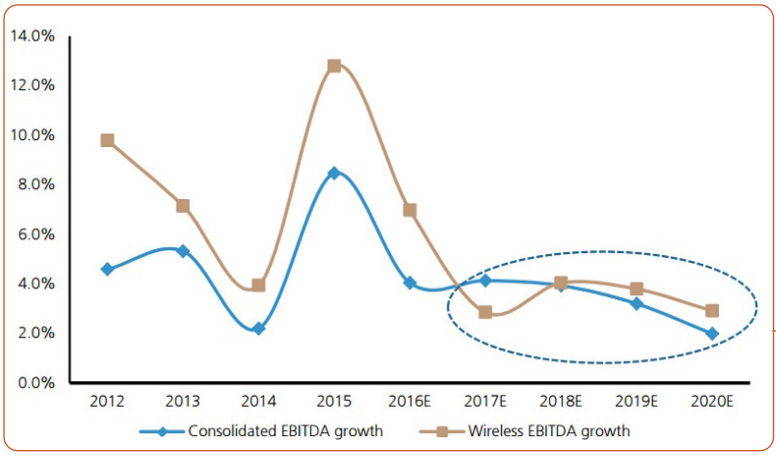
More than three-fourths of the world's mobile data traffic will be video by 2021. Mobile video will grow at a CAGR of 54% between 2016 and 2021, higher than the overall average mobile traffic CAGR of 47%.



Between 2011 and 2015, the CAGR for Amazon Prime members[3] was 92%. This growth is correlated with introducing Amazon Prime Video free to all Amazon Prime members in Feb 2011. Amazon Prime is just one example of strong influence of OTT video consumer online activities.



Decelerating Growth of Mobile Revenue

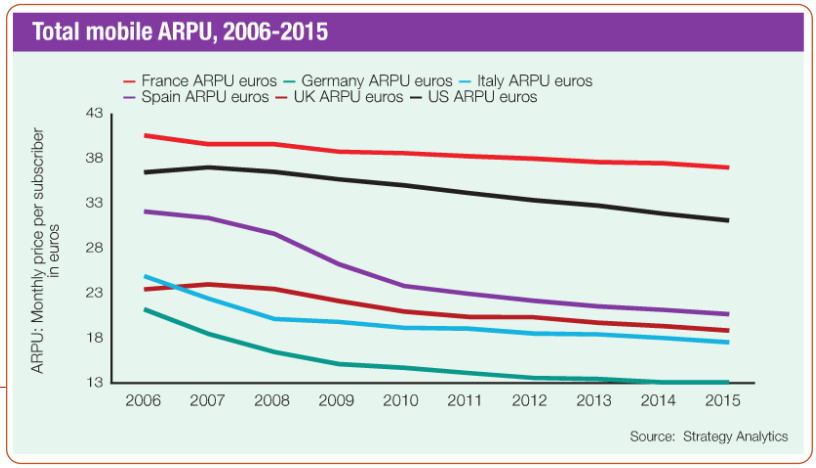


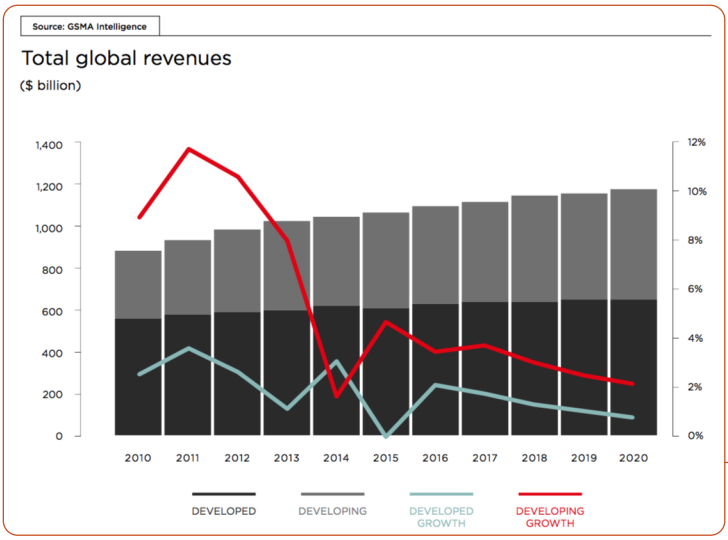
EBITDA Decline

While mobile operators still enjoy reasonably large operating margins, their earning growth started to decline in 2016. According to UBS[4]: earning growth for US wireless operators has peaked in 2015; it will continue to decline or be flat for the next 5 years.

ARPU Decline

Many mobile operators are not on the receiving end of the financial bonus associated with the OTT video boom or mobile data explosion. In recent years, the ARPU for most mobile operators has been flat or declining:





Negative Revenue Growth

According to GSMA Intelligence[5], the total global revenue growth for mobile operators in both developed nations and developing nations will be lower than 2%.

GSMA Intelligence[6] estimates the total global revenue for all mobile operators was 1.06 Trillion USD in FY 2015, representing 2.18% growth from the prior year, while the ARPU per month was $10.25 in FY 2015, representing negative growth at -2.78%.

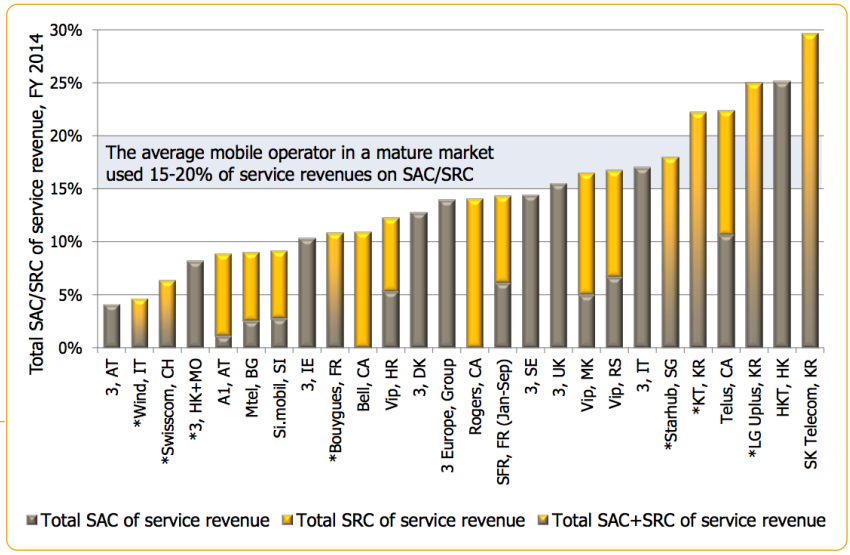
Productivity Challenge for Mobile Operators

In 2017, mobile operators face slow growth with increasing pressure to upgrade their network capacity. According to a special report from the Economists Intelligence Unit[7] (EIU), mobile operators have found it difficult to monetize offerings such as fixed wireless broadband. Besides spectrum constraints and investment for 5G evolution, operators face competition from providers of OTT services like Netflix, YouTube, Amazon, and Facebook/WhatsApp, whose online offerings are spreading worldwide.

A recognized new source of revenue is business related to the internet of things (IoT). In a recent report by Citigroup, the banking giant argued for telecom operators to embrace the "digital transformation" and to do more to develop IoT technologies such as mobile banking, cloud-based TV, smart home functionality, and e-health. In the first quarter of 2016, vehicle connectivity was responsible for 32% of cellular connections in the US, outstripping phones (31%) and tablets (23%), according to Chetan Sharma, a consulting firm.

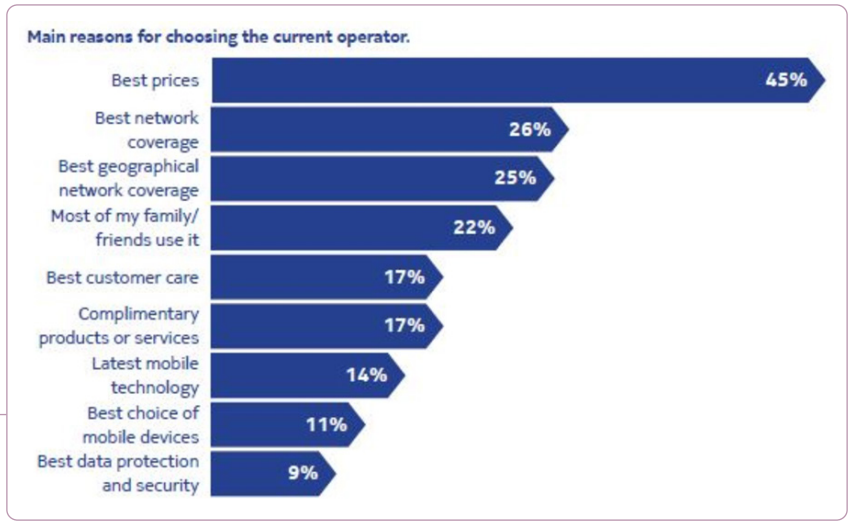
All these recommendations and predictions are predicated on heavy investment in network infrastructure. In such environments, all operators have to look carefully at their strategies for capacity expansion.

All mobile operators are facing a productivity challenge. According to Tefficient[8], mobile operators as a group spend approximately 15%-20% of their revenue just to retain their customers.



Network Quality is Critical to Avoid Churn

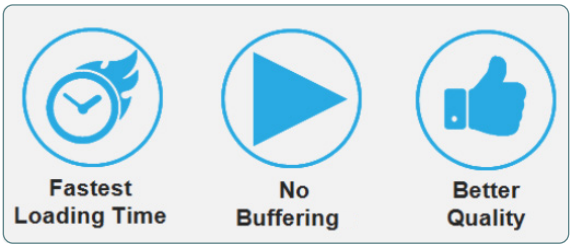
According to a Nokia 2016 Acquisition and Retention Study[9] summary report, Network Quality is the second most important factor for subscriber retention. While the importance subscribers place on Network Quality varies between operators, dissatisfaction with Network Quality is closely linked with the likelihood to switch. In fact, 42% of subscribers claiming to be very dissatisfied with their Network Quality would like to switch as soon as possible.



Video Quality of Experience Requires Bandwidth

As video becomes the dominant type of mobile media, consumers are increasingly sensitive to QoE issues in watching videos. This problem will be exacerbated by the coming of 4K videos. Based on the research by Conviva, all 3 critical factors for QoE for video viewing are dependent on bandwidth. Higher bandwidth is becoming the dominant factor in subscriber QoE and churn rate for mobile operators. According to a study from Conviva[10], major providers of the online video streaming market lost $2.16B in revenue in 2012 due to video problems, and will miss out on an additional $20B in 2017. The top 3 problems that cause viewers to abandon viewing are: long startup delays, frequent buffering, and low video quality.

Three critical factors recognized by Conviva for video QoE require bandwidth:



Load Time: shorter load time requires higher bandwidth

Buffering: less buffering requires consistent bandwidth

Video Quality: better video quality requires higher bandwidth

According to Conviva[11], viewers have become intolerant of poor video quality:

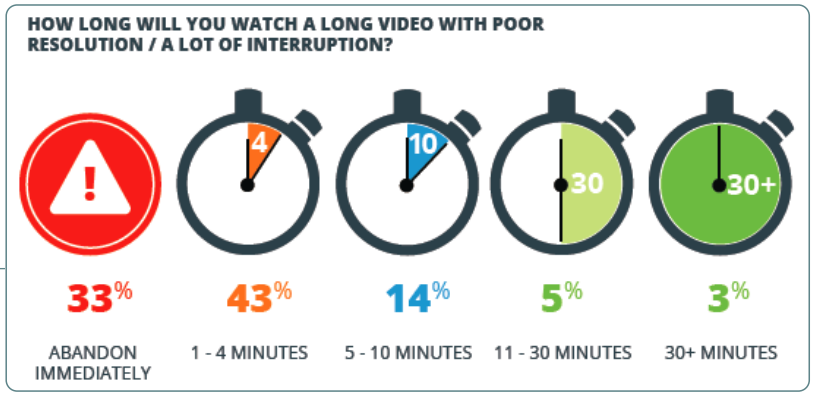
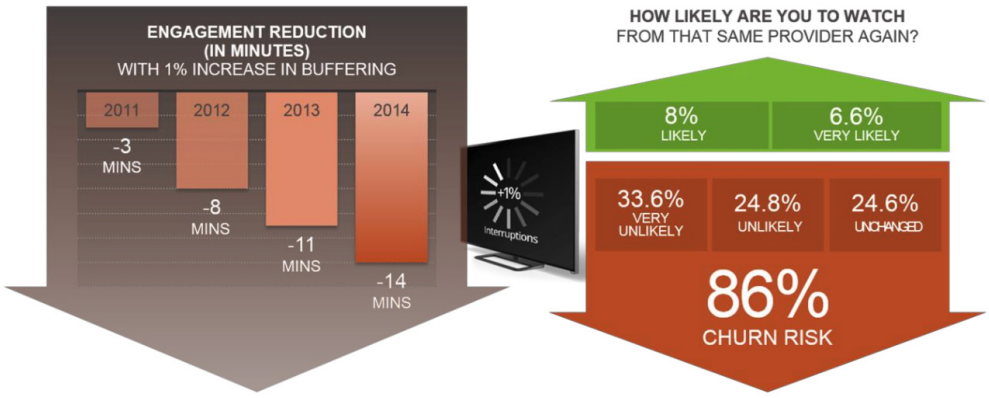


Figure 4: Service Delivery Issues & Abandonment



Source: Conviva, "2015 Consumer Survey Report," 300 responses

In a survey done by Conviva[12], a provider runs a churn risk of 86% for a mere 1% increase in video buffering:

Content Should be Pushed to the Edge

Today, as broadband connection to the Internet becomes affordable, users are accustomed to high-bandwidth consuming applications, causing the overall Internet traffic to grow at a 30%-50% annual pace. Consequently, cable operators, telcos and other communications service providers (CSPs) find themselves in a bind. According to HeavyReading[13], CSPs are seeing their backbone networks increasingly filling beyond the breaking point.

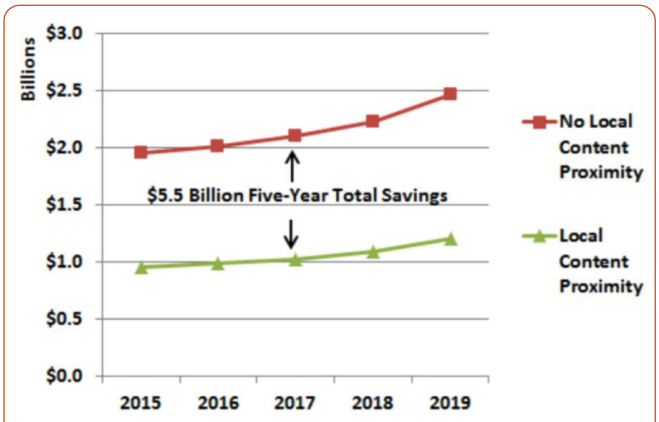
Additionally, CSPs find their total network transport costs soaring, even though the cost per port or data packet continues to decline. Despite their best efforts, the problems caused by surging network traffic are easily outpacing the benefits achieved by improving their network efficiencies.

To solve the traffic clogging problem, a number of firms such as HeavyReading, ACG Research, Conviva, EdgeConneX, etc., now advocate pushing data to the edge.

In a study conducted in 2015 for EdgeConneX, ACG Research[14] found that, for a metro area with 1 million subscribers, introducing local content proximity could generate $110 million in backbone transport cost savings over a five-year span.

That would amount to a 50% cost reduction over the current long-haul transport method.

If this approach is adopted in the CSP industry, this will translate into huge backbone savings and cost reduction. According to ACG Research, bringing a majority of content to the edge for 50 million households would save the industry $5.5 billion over the course of five years.



Source: ACG Research

In separate research by Conviva[15], localized caching improves video rebuffering by significant amounts.

In comparative trials in Boston, Norfolk, Las Vegas, and San Diego in 2015, Conviva found that edge datacenters allow ISPs and CDNs to produce lower video rebuffering rates for their subscribers. In Norfolk, for instance, Conviva reported that the rebuffering rate improved 37% for end users on one ISP's network, while the rebuffering rate improved nearly 35% for Akamai users on the second ISP's network.

According to a study by TDF Group[16] (a French broadband and mobile network operator), a promising recourse to the surging network traffic in France is replacing redundant and repeated transmissions in unicasts by multicasts.

In the TDF study, a multicast network which would cover about 30% of the population of France (main cities) could offload 220 PB out of the 500 PB transmitted on the cellular network for this population. The 220 PB offload would be achieved by multicasting only 1 TB of popular content, equivalent to a reduction factor of 200,000. Using this approach, the estimated savings in transport cost over the 10-year period of 2016-2025 would exceed €10 Bn.

The multicasting approach, while not feasible for many applications, is along the same line of reasoning for pushing content to the edge.

	Same MSO, Two Different CDNs (One Local, One Not)	Two Different MSOs Using the Same CDN (One Connecting to a Local Cache, One Not)
Boston	Localization improves rebuffering 32%	Localization improves rebuffering 12%
Norfolk	Localization improves rebuffering 37%	Localization improves rebuffering 35%

Source: Conviva

Content at the Mobile Edge is Coming with 5G

Pushing content to the mobile edge is coming with 5G. Today, Mobile Edge Computing (MEC) is being standardized along with other 5G-related standards.

One of the first places mobile networks will be transformed with 5G is in cellular base stations. As part of the MEC initiatives[17], operators plan to enable applications to run at the edge, or at the base stations. This will reduce the network latency experienced by an end user accessing an application over a mobile network.

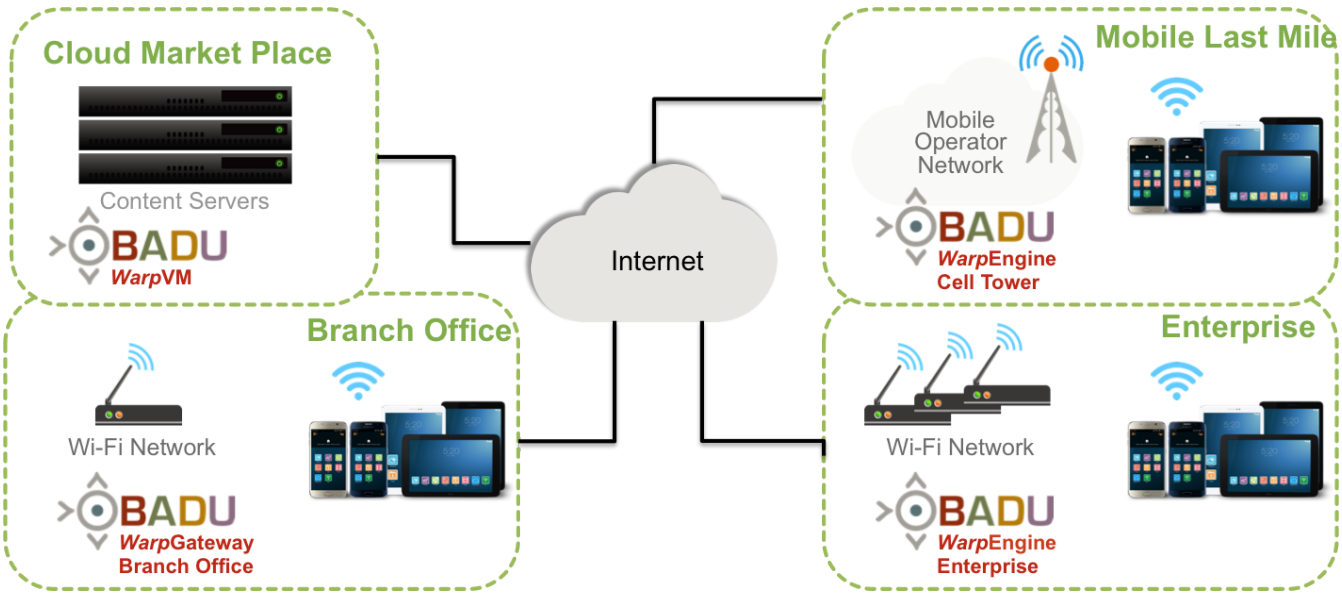
With MEC, the RAN (radio access network) edge becomes a new value center for mobile operators. Content served from the RAN edge not only saves the operators 50% (ACG Research) in back-haul and long-haul transport costs, but also provides the best possible user experience by minimizing the latency between the content server and the customer device. This is a fundamental advantage, only enjoyable by the mobile operators.

Knowledge of real-time radio network conditions and context information (such as location) can be used to optimize the network and service operation. This would improve service experience and utilization of network resources, by optimizing traffic with more flexibility and reduced load.

MEC enables new value chains, fresh business opportunities, and a myriad of new use cases across multiple sectors. MEC enables a computing environment characterized by low latency, proximity, high bandwidth, and real-time insight into radio networks. All these features can translate into value for mobile operators, application providers, and content providers. MEC also allows providers to play complementary and profitable roles within their respective business models, by better monetizing mobile data experiences.

Badu WarpTCP — TCP Optimization at Mobile Edge

At this writing, Badu's *Warp*TCP is the only GTP-compatible TCP proxy and caching solution installable at the base station. Badu's *Warp*TCP solution has been field-tested with a tier-1 mobile operator in USA and a tier-1 mobile operator in China.



Badu WarpTCP — Solving the TCP Bottleneck Problem

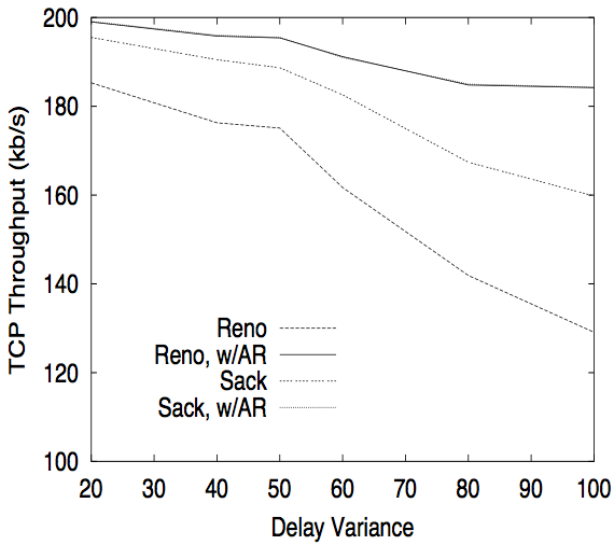
Badu's *Warp*TCP technology suite is the only one in the industry that solves a critical problem in data transport between servers and clients. While CSPs and mobile operators provide a bandwidth infrastructure to deliver data to and from a server or a client, Badu's *Warp*TCP ensures network bandwidth is utilized at a high level. High utilization is critical as it lowers the capital and operating expenditures for owning a bandwidth infrastructure.

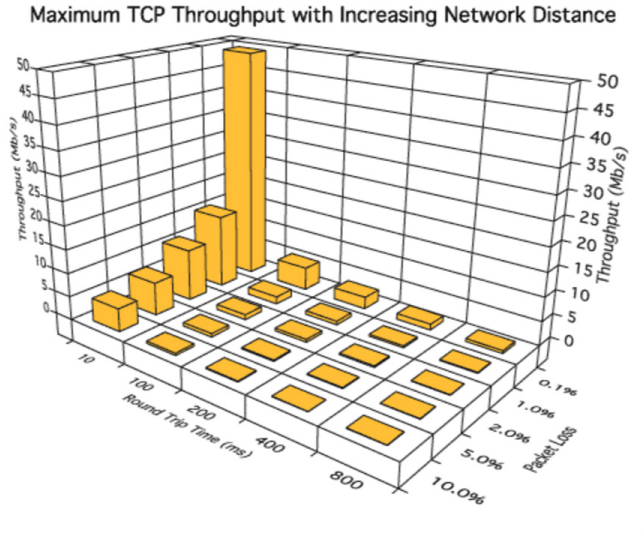
TCP is a cause of concern because TCP will often prevent a server (for download) or a client (for upload) from sending data to the designated receiver. This is a problem inherited from the simple end-to-end feedback control grounded in the TCP design objectives. While this design allows TCP to operate under all types of network condition, it also causes TCP to be overly conservative when the network path encounters various types of jitter.

The TCP slowdown can be large or small — however, as the modern mobile network becomes highly complex, small amounts of jitter can cause transport bandwidth utilization to drop by a significant amount for a significant amount of time. A common TCP slowdown can be experienced at a Wi-Fi hotspot. When there are more than 5-10 devices attached to a hotspot, total utilization of the available bandwidth at the hotspot can drop to 5%-10%. In such hotspots, there is usually no shortage of Wi-Fi or backhaul bandwidth — the problem is that the servers or clients are stopped by TCP transmission control.

Badu's *Warp*TCP solution solves the TCP bottleneck problem. TCP slowdown wastes transport bandwidth and causes user dissatisfaction, which leads to churn at mobile operators.

This diagram[18] shows TCP slowdown in reaction to end-to-end delay variance.

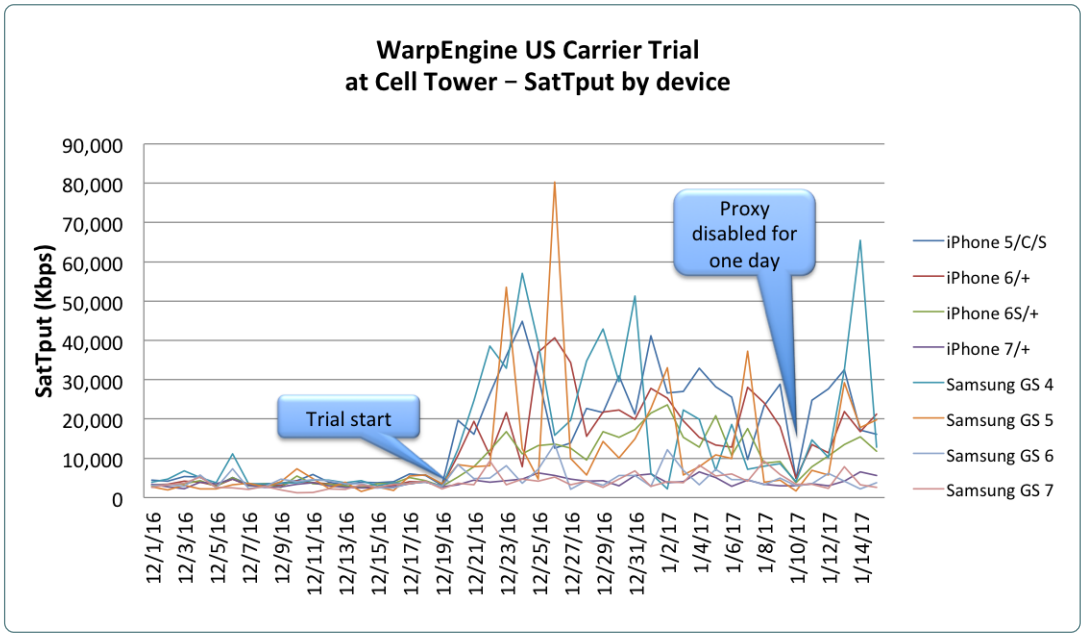




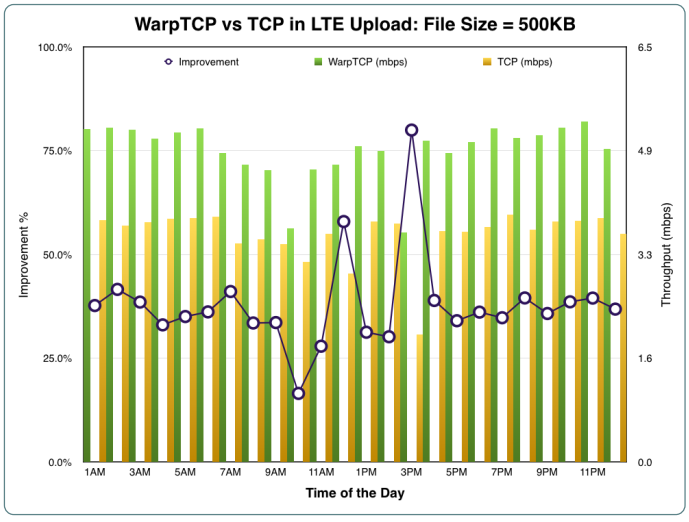
This diagram[19] shows exponential TCP slowdown in reaction to RTT (round-trip time) and packet loss.

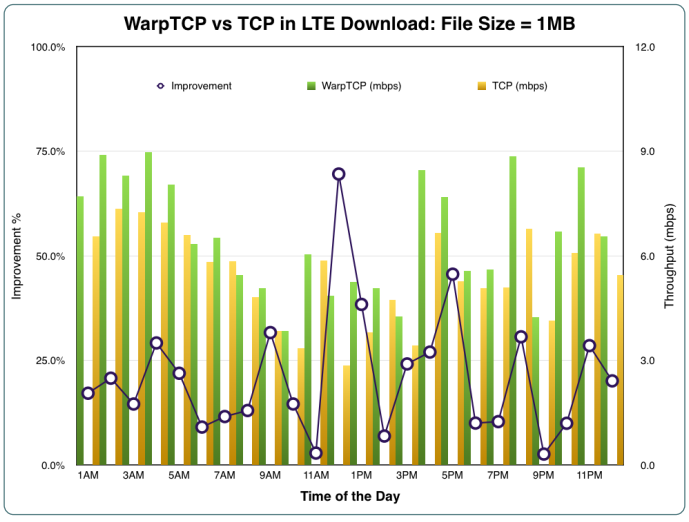
U.S. Mobile Operator Case Study

In this US carrier, the saturation throughput[20] measured at the base station after Badu's *Warp*TCP was installed skyrocketed 5-10 times for many mobile devices:



In this US carrier, a field download test with file size of 1MB shows average improvement at 21.3% with 69% peak improvement; a field upload test with file size of 500KB, shows average improvement at 37.9%, with peak improvement at 80%:

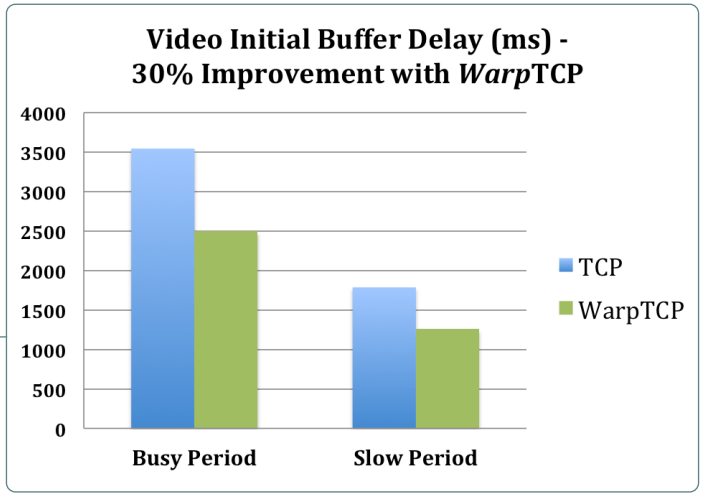


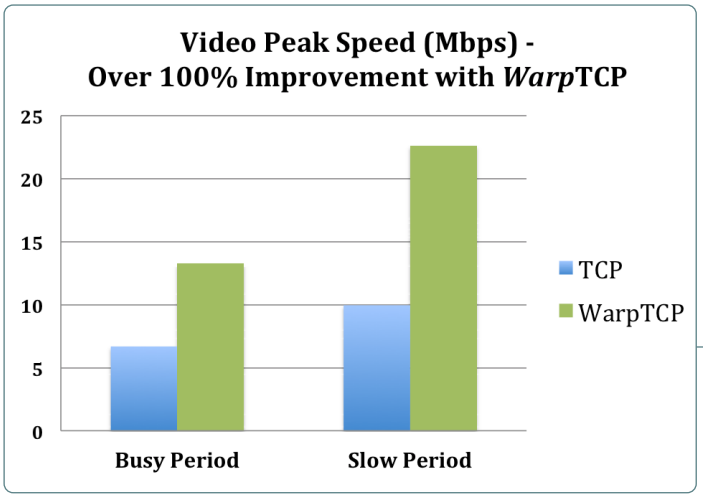


China LTE Operator Case Study

The *Warp*TCP proxy has been deployed at multiple LTE cell sites with a Chinese Operator since the end of 2016. It was independently concluded by the Chinese Operator that the following five operating indicators all saw considerable improvements: TCP throughput, Video streaming download rate, TCP retransmission rate, TCP handshake duration (wireless side), RTT (terminal side).

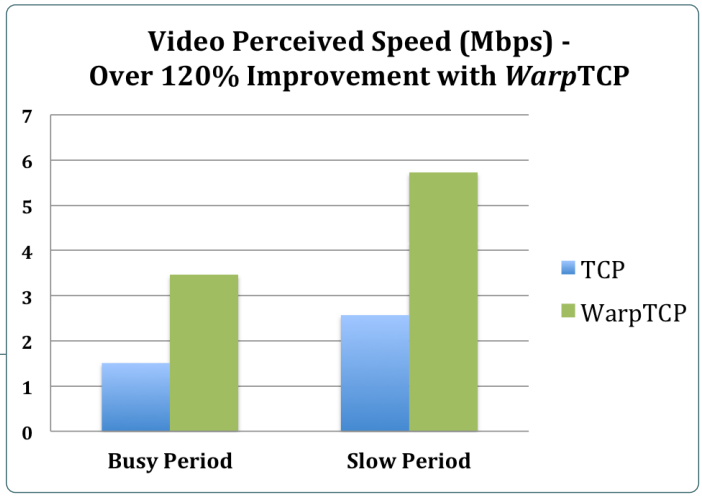
Video Buffer Initial Delay
During a time of heavy traffic, *Warp*TCP lowered the video buffer initial delay by 1059.33 ms, or a decrease of 29.8%. During a time of slow traffic, *Warp*TCP lowered the delay by 537.66 ms, or a decrease of 30.09%.





Video Peak Buffer Speed
During a time of heavy traffic, *Warp*TCP raised the video peak buffer speed by 6.57 mbps, or an increase of 98.21%. During a time of slow traffic, *Warp*TCP raised the video peak buffer speed by 12.57 mbps, or an increase of 127.21%.

Video Perceived Speed
During a time of heavy traffic, *Warp*TCP raised the video perceived speed by 1.95 mbps, or an increase of 129.12%. During a time of slow traffic, *Warp*TCP raised the perceived speed to 3.16 mbps, or an increase of 122.96%.



Comparative Cost for Badu's WarpTCP

Badu's *Warp*TCP 1G-CT is a box that delivers 1Gbps (uplink and downlink), which is installable at a typical LTE cell site. The machine is priced at $50,000 (MSRP) for a maximum-speed LTE site. To compute the production cost per GB for a typical operator, we assume the box is installed at a LTE-A site with maximum speed of 1Gpbs (uplink or downlink), with utilization at 40%[21] and uplink traffic being 30%[22] of downlink traffic. Assuming the CapEx for the 1G-CT box is depreciated over 3 years, then the base production cost per GB is $0.0081, which is computed as $50,000 divided by 6.1495 million GB (total number of bytes delivered in the depreciation period).

To compute the production cost per GB for an operator, we will use the published industry data from various sources. According to GSMA Intelligence, the average ARPU for global mobile operators for FY 2015 was $10.25. Based on UBS and GSMA Intelligence, the average ARPU for 2016 was flat or lower than the ARPU for 2015. Therefore, we will take $10 for the average ARPU for global operators in 2016. According to an Ericsson[23] study, average network OpEx for operators is 5% of revenue, while depreciation network CapEx is 8% of revenue. The Ericsson report is based on depreciation over 8 years in hardware and 3 years for software.

According to Cisco VNI[24], the average mobile data consumption per month globally was 1.6 GB for 2016. Assuming ARPU = $10, and 8% of ARPU is used for CapEx for the LTE site, then the cost for delivering 1.6 GB per user per month is $0.8 (= $10*8%). To provide x% improvement in bandwidth, the cost will be proportionally scaled up by x% — if the improvement in BW (bandwidth) is 5%, then the LTE CapEx will be $0.8*0.05 = $0.04 (see the corresponding entry in the table below).

Next, we account for increased BW because of the installed *Warp*TCP 1G-CT. If the extra bandwidth delivered by *Warp*TCP is x%, the production cost per GB for the *Warp*TCP is to be adjusted proportionally. With the base CapEx for deploying *Warp*TCP being $0.0081, the adjusted CapEx cost per GB will be $0.0081/(1+x%), when the bandwidth improvement is x%. Assuming the user is using 1.6 GB per month without Badu, the actual data used in GB per user per month with x% bandwidth improvement will be adjusted to 1.6*(1+x%). Therefore, the production cost of deploying *Warp*TCP per user per month is $0.0081*1.6*(1+x%)/(1+x%) = $0.013, which is independent of the improvement ratio.

The following table lists the cost ratio between LTE CapEx, delivering 1.6GB per user per month, and the Badu's *Warp*TCP CapEx, for BW improvement ratio ranging from 5% to 50%.

BW Improvement %	LTE CapEx	Badu CapEx	Cost Ratio
5%	$0.04	$0.013	3.1
10%	$0.08	$0.013	6.1
15%	$0.12	$0.013	9.2
20%	$0.16	$0.013	12.3
25%	$0.20	$0.013	15.4
30%	$0.24	$0.013	18.4
35%	$0.28	$0.013	21.5
40%	$0.32	$0.013	24.6
45%	$0.36	$0.013	27.7
50%	$0.40	$0.013	30.7

Therefore, **Badu** has an excellent cost advantage.
Even at improvement ratio of **5%**, the cost advantage is **3.1 times**.

Benefits in Churn due to Badu's WarpTCP

Churn rate has been one of the top concerns for all mobile operators. According to Tefficient[25], the blended churn rate for global operators in 2016 was 25% annually. According to a Nokia study[26], the global churn rate in 2016 was 14% annually. We will take the average of the 2 reports, and use 19.5% as the assumed global churn rate — this translates into 1.495% monthly churn. According to Tefficient[27], the average spending for SRC+SAC by global operators was 15%-20% of service revenue — we will assume 17.5% of ARPU is used for reducing churn.

Therefore, the financial value of reducing churn can be computed based on the global average ARPU at $10 — every 100% drop in churn per user per month is worth ARPU*17.5%/1.495% = $10*17.5/1.5 = $117.06. Therefore, $117.06 is the value of reducing the churn by 100% per user per month.

To quantify benefits in churn, we will employ an artificial ratio R = (percent change in churn)/(percent change in BW). R reflects the influence in churn due to the single factor of bandwidth improvement. We will assume R = 100: in other words, 50% improvement in bandwidth will produce only 0.5% (reduction) in monthly churn. From user experience point of view, 50% improvement in throughput is quite noticeable for video viewing, 0.5% improvement in monthly churn is a conservative estimate.

BW Improv %	Churn Improv/M	Return	Badu CapEx	ROI ratio
5%	0.05%	$0.06	$0.013	4.5
10%	0.10%	$0.12	$0.013	9.0
15%	0.15%	$0.18	$0.013	13.5
20%	0.20%	$0.23	$0.013	18.0
25%	0.25%	$0.29	$0.013	22.5
30%	0.30%	$0.35	$0.013	27.0
35%	0.35%	$0.41	$0.013	31.5
40%	0.40%	$0.47	$0.013	36.0
45%	0.45%	$0.53	$0.013	40.5
50%	0.50%	$0.59	$0.013	45.0

Badu has an excellent ROI advantage.
Even at bandwidth improvement ratio of **5%**, the ROI ratio is **4.5 times**.

Conclusion

Bandwidth is money, especially for mobile operators, as any investment to expand network capacity is a costly proposition. Capacity expansion is critical for profitability for mobile operators. Moving content to the edge will save about 50% of backhaul and long-haul bandwidth cost. Adoption of a TCP de-bottleneck solution will improve efficiency for existing bandwidths.

With the advent of 4K video, the pressure of surging mobile data traffic has to be dealt with using the highest leverage of the existing bandwidth infrastructure. Badu's *Warp*TCP is the only TCP de-bottleneck solution that can be deployed at any location in the network.

It is time to take action to improve profitability and productivity for mobile operators.

To request a demo, visit: **www.BADUnetworks.com**.

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