TRANSITIONING TO IP

Moving Full-Time Channel Distribution from Satellite to Terrestrial IP Networks Without Losing Sleep: An Introduction to LTN’s Dynamic Multi-Carrier Routing Architecture

A WHITE PAPER BY LTN GLOBAL

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# TABLE OF CONTENTS

2  Executive Summary

4  Content Evolution and Transition to IP Transport

8  Internet Architecture and Its Limitations

11  LTN’s Highly Resilient Dynamic Multi-carrier Routing (DMR) Architecture

16  LTN’s Network Routing Data

19  LTN Real Traffic Routing Behavior Analysis

22  Benefits of LTN service

26  The LTN Advantage

28  Contact Us
Executive Summary

Technology innovation and resulting shifts in consumer behavior have led to a period of rapid change in the media industry. As broadband and wireless Internet has expanded worldwide and an increasing variety of connected consumer devices have come to market, the decades-old model of delivering one version of content to a mass audience through traditional broadcast, cable, and direct-to-home satellite channels has become inadequate. Content companies now need to reach consumers through new distribution channels including social media, direct-to-consumer websites and over-the-top (OTT) platforms, and create multiple versions of their programming tailored to a diverse set of devices, geographies, languages and cultures.

This new level of content customization has put pressure on the professional video transport chain, which traditionally has relied on satellite or fiber links to deliver content from a programmer to the distribution outlets with which they do business. The high cost and limited capacity of satellite transmission limits the number and quality of program variants that a content company can reasonably provide to consumers. At the same time, satellite frequencies are being sought by regulatory bodies worldwide as a means to deliver new wireless services, which is likely to lead to an overall reduction in the capacity available to traditional media companies for content distribution.

Given these trends, content companies are exploring using IP-based terrestrial transmission, including both private networks and the public Internet, as an alternative means of delivering their product. But private IP networks such as MPLS are expensive, and the public Internet has some basic architectural limitations that make it difficult as a means to reliably send high-value content, particularly live programming.

However, the challenges of the Internet's underlying architecture can be overcome and reliable, cost-effective delivery of live content achieved through the application of unique “overlay” technology and the development of a professional network of data centers using proprietary routing protocols. Content transport provider LTN Global
Communications has done just that, creating a fully managed service that delivers live content today for some of the world’s biggest media companies with equal or better reliability than traditional satellite or fiber paths.

This white paper will examine the content delivery challenge faced by media companies today; describe the potential solution of the public Internet and the inherent difficulties it bears; and more important, explain the unique, patented technology and powerful data network that LTN has created in order to solve the problem.
Content Evolution and Transition to IP Transport

This is a time of rapid change in the media industry, especially in video transport and delivery. The content chain from playout all the way to the consumer is evolving, driven by significant shifts in content regionalization, technology, regulation and consumer behavior.

Content providers now reach consumers through a variety of distribution channels beyond traditional cable and direct-to-home satellite outlets, including social media sites, direct-to-consumer websites, over-the-top (OTT) platforms and international distribution sites. And in order to monetize content optimally, providers are pursuing consumers and advertisers across diverse geographies, devices, languages and cultures.

Each of these points of distribution can require varying levels of content customization: closed captioning; audio translation; graphics; advertisements; subtitling; and sometimes even changes in the underlying content itself. Some content providers are exploring cloud-based content customization in order to cost-effectively produce multiple versions and efficiently adapt content to suit local markets and specialized devices.

These changes in content preparation are having a profound impact on program distribution. The days of one version of content broadcast to any and all takers are rapidly disappearing, replaced by customized versions unique to each specific receiving group. Historically, content owners have provided their content on satellite transponders in the geographies where they did business and left it to their distribution outlets to downlink that content and deliver it to consumers. But given the expense of satellite transport, the number of possible variations of channels is limited and the quality of the content has to be capped to fit the amount of satellite bandwidth leased by the content provider. So the aforementioned growth in the number of channel variants is making it difficult for content providers to continue to rely, at least solely, on satellite transport.
Making this capacity crunch worse is the move by regulatory bodies worldwide to carve away spectrum that is currently being used by C-band satellite operators and repurpose it for use by 5G wireless carriers. In response, some of the largest satellite providers in the world have banded together to create the “C-Band Alliance” and proposed that they directly negotiate with 5G carriers to clear out all satellite transmissions and downlink users from a portion of the C-Band spectrum and dedicate it for 5G use. Regardless of how the C-Band situation plays out, with either public auction of spectrum or private commercial arrangements for it, overall satellite capacity will decrease at a time when the amount and variety of content needing transport is growing rapidly.

Recognizing these fundamental trends, content providers have started to explore alternative methods of delivering their programming to distribution outlets. IP-enabled terrestrial transmission paths are the most obvious and attractive alternative, given their flexibility to route traffic easily from anywhere on the network to anywhere else without the necessity of creating a physical end-to-end path.

The economics of IP-based networks vary significantly by architecture but they are generally favorable compared to satellite, especially if there is an emphasis on increasing content regionalization or localization. However, the more “private” the network, the higher the cost of transport.

Over the past few decades, last mile Internet bandwidth has continued to grow at the rate of about 30% each year, while cost of bandwidth has been declining at about 30% per year.
MPLS networks fall into this category. Last-mile connections to MPLS networks require dedicated connections from each end point into the MPLS backbone. This can get very expensive as the number of end points grow. Additionally, MPLS service is limited to a single carrier’s network, with the risk of a single carrier’s failure. For these reasons, MPLS networks are generally not practical for broad content distribution.

Internet-based delivery holds the best promise for next-generation content transport. It is available ubiquitously worldwide, and the amount of available Internet last-mile bandwidth has been growing at ~30% per year for the last few decades, while the cost-per-unit of Internet bandwidth has been declining at ~30% per year over the same timeframe.

The Internet has absorbed multiple messaging methods over the last 20 years. Mail has morphed to email, faxes to PDFs and landline phones to voice-over-IP. Now we are experiencing explosive growth in the amount of video being transported over the Internet. Most of this growth has been in on-demand video over the last two decades, but live and real-time Internet video traffic is starting to grow rapidly.
However, there are some fundamental issues that must be addressed before the Internet can be used to transport high-value, live or real-time, professional content in a reliable and secure manner. As the graph above shows, analysts are rightly concerned about the ability of the Internet to reliably transport live video. The trend towards Internet-based transport for even live and real-time video content is clear, but it is also clear that the raw Internet was not designed to support real-time traffic.
Internet Architecture and Its Limitations

In this context, it is helpful to look briefly at how the Internet is architected. What we all think of as a singular Internet is really a collection of around 60,000 independent Internet Service Provider (ISP) networks worldwide that all follow the same general principles in how they build and operate their networks, and how they connect to each other.

Each ISP network is built using IP protocols running over a physical network consisting of fiber connectivity with routers and switches that route traffic internally, normally using the Open Shortest Path First (OSPF) protocol. This protocol’s job is to select the shortest path reliably from the ingest point to the egress point on the ISP’s own network.

One important constraint is that these ISP networks do have a form of hierarchy, where the amount of bandwidth they offer customers always greatly exceeds the amount of bandwidth available in the core of the network. This is normally not an issue, because these Internet last miles are used by a fraction of the total users simultaneously. However, during periods of unusually high traffic usage, aggregation points of customer traffic can get overwhelmed and traffic subsequently slows down in long queues.

Once a queue is formed, all packets in that queue are delayed. Internet routing protocols are not designed to route around congestion, only on link failure. Therefore, if a series of packets are stuck in a queue, they simply have to wait patiently until it is cleared. Further, when queue lengths exceed the capacity of switches, packets are dropped.

While dropped packets can be detected at the destination application and recovered to support reliable communication, this typically incurs further delays; the dropped packet and all following packets are delayed until a retransmission request is sent all the way back to the source, the dropped packet is recovered, and all packets can be delivered in order.
These independent ISPs have to frequently exchange traffic with each other, since most Internet users look for connectivity to other users or servers that are normally not on the same ISP network. This exchange is done using a Border Gateway Protocol (BGP), whose policies are usually commercial in nature.

Two equal-sized ISPs may agree to exchange content at no cost to each other, as long as they send and receive roughly the same amount of traffic to and from each other in private or public peering arrangements. Non-equal ISPs frequently sign transit agreements that require payment.

In either case, these arrangements are frequently capped in terms of capacity. While these caps are built with real traffic trends in mind, rarely are they built for peak traffic. During those abnormal traffic conditions, an ISP may deliberately send traffic to non-optimal transit or peering points. Or traffic can get stuck behind long queues since the bandwidth is capped. Both of these events cause delay and possible packet loss, as described above.

Internet architecture is built around the principle of a simple and efficient core with most of the intelligence built on the edge. For example, Transmission Control Protocol (TCP)-based end points request lost or missing packets and wait until those packets eventually show up. This, in turn, allows Internet traffic to get from one end to the other reliably, but with an uncertain delay. For applications that require low delay and are loss-tolerant, a special protocol called User Datagram Protocol (UDP) was created. This protocol does not attempt to recover packets on an end-to-end basis, and lost packets remain lost, so UDP trades off reliability in order to achieve low delay.
Neither of these protocols serves the need of live or real-time video applications that must be both reliably received and stay within a narrow latency window. This problem is magnified by these transport protocols' reliance on Internet routing with its associated problems mentioned above. Handling real-time applications like these over the Internet requires further processing than is available within the Internet's simple core.

There is a further architectural limitation to the Internet that fundamentally restricts its use for content delivery to multiple destinations. The Internet does not have any native ability to multicast, i.e. to send the same packet from one source to multiple receivers. Instead, the Internet is built as a unicast system. This means that in order to send a single video feed to multiple destinations, the source location has to send multiple copies of the same content, one copy for each destination. This quickly becomes unusable and impractical as the number of receivers grows beyond just a few.

**Inherent Limitations of the Internet**

- Customers considering moving from satellite to an Internet-based transport solution must take great care to ensure that their chosen Internet solution has the ability to overcome these challenges.
- Many of these transport issues occur in the middle of the Internet and thus cannot be solved by technology that sits at the edge of the Internet.

These inherent limitations of the Internet make it less than practical as a substitute for satellite delivery without some way of overcoming these limitations. Customers considering moving from satellite to an Internet-based transport solution must take great care to ensure that their chosen Internet solution has the ability to overcome these challenges. Many of these transport issues occur in the middle of the Internet and thus cannot be solved by technology that sits at the edge of the Internet.
LTN’s Highly Resilient Dynamic Multi-carrier Routing (DMR) Architecture

To solve these Internet limitations, LTN has developed innovative and patented technology including Rapid Error Recovery (RER) protocols and Dynamic Multi-carrier Routing (DMR) algorithms and architecture. It has also built a global backbone network around this technology. This two-pronged effort allows us to provide our customers a very high-reliability, fully-managed video transport service over the Internet. This robust transport service also allows LTN to offer our customers very exacting Service Level Agreements (SLAs), whose metrics include reliability, availability and latency. These SLA metrics match or exceed those available from satellite or fiber service. LTN’s service has already been deployed by many of the world’s largest and most demanding media companies to distribute high-value, full-time channels worldwide.

The diagram below shows a high-level view of the LTN network. Client appliances connect to data centers on the LTN network. Each data center has access to multiple carrier networks. Traffic can flow between clients and data centers or between data centers over multiple carrier paths.

LTN’s Proprietary Dynamic Multi-Carrier Routing (DMR) algorithms automatically and losslessly route live customer traffic around congested or delayed carrier paths.

LTN’s Dynamic Multi-carrier Routing (DMR) network architecture is built on a few important underlying principles.
First, LTN puts routing and processing intelligence in the middle of the Internet located in high-availability and secure data centers all over the world. This intelligence allows the LTN network to process data, monitor traffic and make decisions that would otherwise not be possible over the Internet. One example of this is that LTN runs a proprietary error-correction protocol, Rapid Error Recovery (RER), on each individual segment of the end-to-end path on the LTN network. RER enables rapid loss recovery in 10-20 milliseconds, rather than normal end-to-end recovery between the source site and a receive site that may take 100’s, or even 1000’s, of milliseconds. This proprietary feature allows LTN to withstand significant underlying loss on the Internet link, recover the loss very rapidly and deliver the traffic to an end site, while staying within a small end-to-end latency budget of <200 milliseconds within US or <300 milliseconds worldwide.

Another benefit of having this intelligence in the middle of the Internet is that it allows LTN to decide which data center is closest to each receiver out of a group of receivers, and to serve out multiple copies of a feed only at those last-mile data centers. All other data centers thus act as transit points and simply route a single copy of the feed to the next data center on the flow route. This innovation in data routing allows LTN to broadcast live and real-time video feeds reliably and with low latency to hundreds and even thousands of end points efficiently and cost-effectively. As a result, LTN deploys unique multicast technology that is able to run over the Internet’s unicast architecture, delivering a high quality and reliable broadcast service while leveraging a ubiquitous public resource.

Second, these LTN data centers are all highly secure sites with access to multiple Tier 1 ISP’s core IP networks, allowing LTN’s backbone servers to route traffic from one carrier’s network to a second, or even a third, based on the health of each carrier’s Internet link. The availability of a multi-carrier grid at each data center, along with LTN’s...
real-time monitoring of each link, near-instantaneous messaging system and patented rapid routing algorithms, allows LTN to reroute live and real-time audio/video traffic inside its data centers in milliseconds from one carrier plane to another. The LTN network’s unique ability to reroute around issues of increased congestion, contention, delay or even sudden unavailability on single or even multiple carriers in milliseconds allows LTN to consistently distribute content with extremely high reliability and very low delay.

In the diagram shown above one can see Dynamic Multi-carrier Routing (DMR) in action:

1. A feed enters the LTN network into a data center from a client shown on the right.
2. The LTN network chooses the carrier plane shown in red as the primary path to receive and send the feed to the next data center on its way to the destination.
3. At the second data center, the network detects performance degradation on the red carrier.
4. The LTN network switches the feed to the blue carrier, and sends the feed to the next data center in the chain on that blue carrier plane.
5. At the third data center, the network detects an issue with the blue carrier leaving the third data center.
6. The LTN network re-routes the feed to the green carrier plan, which is also how the destination client receives it.

With DMR the customer’s feed has been rerouted over three different Tier 1 carrier backbones end-to-end automatically, with no impact on the users, and within the performance SLA’s of 99.999% or higher availability and reliability and <200 milliseconds.
latency. Without the LTN network monitoring and intelligently rerouting traffic in real-time around congestion, contention, long queues or unavailable links, the feed would have suffered from loss, long latency, jitter or unavailability. LTN’s DMR architecture and its underlying algorithms ensure the timely arrival of this traffic flow unimpeded and unaffected by any underlying issues on any single, or even multiple, Internet backbone carriers.

Dynamic Multi-carrier Routing Principles

1. Routing and processing intelligence in the middle of the internet
2. Highly secure sites, multiple Tier 1 ISP’s core IP networks enables routing across multiple carriers and real time monitoring of each path
3. Flow based architecture ensures packet protection within each flow

This innovative and patented DMR architecture allows LTN to use the Internet’s massive and ubiquitous physical infrastructure for real-time and live video transport, delivering BOTH high reliability AND low latency. LTN is able to deliver exacting Service Level Agreement (SLA) guarantees because our network does not depend on Internet routing to deal with issues at various points in the Internet that reduce reliability and/or increase delay. By investing in a global network of data centers and in multiple Tier 1 backbone carriers with large and scalable bandwidth capacity, along with developing advanced and patented technologies such as DMR and RER, LTN has created an IP delivery system that always routes its traffic on the optimum end-to-end path—even when that path requires routing over multiple carrier backbones. Our SLA includes 5 9’s availability and reliability, while meeting a delay budget of 200 milliseconds within the US and 300 milliseconds worldwide. These exacting SLA’s cannot be consistently delivered without LTN’s investment in decision-making intelligence in the middle of the Internet.

Third, LTN’s architecture is a flow-based overlay over the Internet, rather than a packet-based forwarding system. All packets belonging to a specific flow (e.g., sports event, entertainment channel or newsfeed, etc.) are routed based on the policies for that flow. LTN deploys a fast and accurate messaging system between its data centers that
allows all servers to share current-state information about all flows, ensuring that if a flow is rerouted over a secondary path then all affected data centers on that new path are fully aware of that flow. This messaging approach allows real-time algorithms to reroute flows in milliseconds, secure in the knowledge that the LTN data centers on the new route will have a complete understanding of the policies governing that flow and deliver the flow without interruption to the end customers.

To be clear, the LTN network is an “overlay” on top of the Internet network. No changes are required at any layer of the Internet infrastructure. All LTN algorithms, protocols, and actions are performed at an overlay level on top of the Internet.

Finally, there is one more important factor in ensuring LTN’s reliability as a high value video transport service. LTN has invested in a 24/7 Network Operations Center (NOC) that is staffed by highly trained and experienced technical staff. This NOC is supported by proprietary monitoring, reporting and management tools that allow the staff to quickly isolate and fix issues, including those caused by the customer’s own video/LAN infrastructure or by any of the ISPs involved in the flow. This critical investment allows LTN to meet its exacting SLA’s to customers, and ensures that customers always have LTN support personnel to rely on when things go awry. Often, LTN’s NOC will isolate and fix issues before there is any customer impact. The vast majority of the problems worked on by our NOC turn out not to be issues on the LTN network—but LTN is able to identify them because it has an end-to-end view of the flow extending all the way to problems at customer sites and video networks. LTN also makes monitoring tools available to customers so that they are able to see the health of their traffic over the LTN network.
LTN’s Network Routing Data Architecture

Given our network’s architecture and placement inside the core of the Internet, we are able to collect real traffic data on Internet congestion, as well as to document how LTN’s algorithms have rerouted flows to avoid loss or delay that would have been caused by congestion on the primary path.

To understand the data, it is helpful to understand the flow of customer traffic over the LTN network, as shown in the diagram below.

In this diagram, a simple example is shown of how flows can be routed from a source to a destination over multiple paths. It’s simplified because it shows only three physically separate possible paths. However, as discussed earlier a large permutation of paths is possible and all these paths are available for re-routing, allowing LTN to deliver customer feeds with unprecedented resilience and reliability.

LTN provides a customer-premise appliance that is homed on multiple ingress data centers in the LTN network, and can connect to multiple ISP connections at the
customer premise for redundancy. It also has the ability to terminate on multiple ISP backbones within each data center. This allows traffic from the source site to reach the LTN network over multiple paths. The LTN network automatically chooses the most optimal path as a primary route, and measures and monitors the health of each link every 70 milliseconds. If the health of a link on the primary route starts to show signs of degradation, the network will automatically re-route the traffic to a second path. It is sometimes necessary to re-route the traffic to a third or fourth (and so on) path to ensure that the flow metrics stay within our SLA. These re-routes are made without impact to customer-received traffic. This process exists for the last-mile connection to both the sender and receive site(s).

LTN measures and monitors the health of each link every 70 milliseconds.

For the purposes of this white paper, we show flow data collected for September and October 2018 in the tables below. Our experience is that this data is consistent month-over-month, and this representative sample was collected to show detailed analysis of traffic patterns over the LTN network.

### September 2018

<table>
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<th></th>
<th>Full Time Channels</th>
<th>Occasional Use Feeds</th>
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<tbody>
<tr>
<td># of end-points</td>
<td>1,780</td>
<td>5,704</td>
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<tr>
<td>% of feeds rerouted</td>
<td>29.94%</td>
<td>8.63%</td>
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<tr>
<td>Average # of paths</td>
<td>2.58</td>
<td>2.29</td>
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*LTN network re-routing data around Internet issues (September 2018)*

### October 2018

<table>
<thead>
<tr>
<th></th>
<th>Full Time Channels</th>
<th>Occasional Use Feeds</th>
</tr>
</thead>
<tbody>
<tr>
<td># of end-points</td>
<td>1,808</td>
<td>6,602</td>
</tr>
<tr>
<td>% of feeds rerouted</td>
<td>33.57%</td>
<td>9.02%</td>
</tr>
<tr>
<td>Average # of paths</td>
<td>2.57</td>
<td>2.25</td>
</tr>
</tbody>
</table>

*LTN network re-routing data around Internet issues (October 2018)*
The data is divided into two columns, one for full-time channels and the other for occasional use or ad-hoc traffic. The number of end-points is the number of clients for each service during that month. The % of feeds re-routed refers to feeds that were routed away from the primary path for >5% of the time; for full-time channels, that equates to at least 36 hours a month. Re-route data for less than that duration was not counted in this data. Average number of paths is the average number of alternative routes that were used for more than 5% of the time. Traffic that was sent only on a secondary path would register as having had 2 paths. Tertiary path traffic would be recorded as 3 paths. To register as a tertiary path, the traffic would have had to be on the tertiary path for >5% of the time as well.

Without LTN’s overlay network, full-time channels would experience >36 hours of delay or loss per month over the Internet.
LTN Real Traffic Routing Behavior Analysis

There are some important takeaways from the data in the tables above. Reroute percentages are quite high across the board, but especially for full-time channels. This is an important finding since the LTN network reroutes traffic only when packet loss is unavoidable on the primary path – AFTER all attempts at RER packet loss recovery have been deployed!

LTN’s first line of defense is to recover lost packets within a preset delay budget. Our RER protocols for this loss recovery are very advanced and, more importantly, operate on short hops between customer premise appliances and the nearest data centers, as well as between data centers, which are normally 10-20 milliseconds apart. This results in rapid and efficient packet loss recovery, something that is not possible if a customer deploys boxes at its premises without a network in the middle.

However, despite the hop-by-hop packet loss recovery effectiveness of the RER protocols, our second line of defense, the LTN DMR algorithms, still switches away from the primary path for a quarter to a third of the full-time channels in any given month. Had the LTN network not rerouted the traffic, it would have certainly experienced loss, as well as uncertain and variable delay. Internet routing would have waited for a disconnection to reroute traffic, which is accompanied by a long wait (~40 seconds to minutes) for convergence. Without LTN’s network, content flows would have to depend on Internet routing, which is designed NOT to route around congestion, loss, increased delay or any of the normal issues that occur frequently over the Internet’s traffic aggregation, transit or peering infrastructure. Internet routing protocols like OSPF and BGP will only route around links that are broken or otherwise not available, and to route around these broken links, there is a waiting period for reconvergence.

Edge technologies try to counter this reality by either deploying very large buffers (several seconds or even 10’s of seconds), sending multiple packets of the same feed, using methods like forward-error correction (FEC), or by simply deploying end-to-end
Selective packet recovery protocols. These methods all have serious drawbacks. They are not effective since they rely on Internet routing in the middle, and therefore have no recourse if the traffic is blocked at a congested aggregation router, peering point or transit connection. Sending multiple copies of the same feed or retransmitting delayed packets does not help, and in fact can even worsen the situation if there is already a long queue at the congested point.

The only effective solution is to route around these points of congestion, much like motorists use apps like WAZE and Google Maps to find alternative paths to congested routes. Without LTN’s RER hop-by-hop error recovery protocols and DMR re-routing algorithms, content traffic will experience loss and uncertain delays, especially for full-time flows. This is a non-negotiable issue for live and real-time high value content delivery.

LTN, of course, goes one better than road traffic re-routing systems – we guarantee arrival time with consistent reliability! This is, in part, because traffic on the road is restricted to a single two-dimensional system of possible paths to the destination, while LTN adds the third dimension of multiple carrier planes so that our traffic can move from one plane to another rapidly in response to issues. This three-dimensional mesh, and the intelligence to gather information and make routing decisions in real time, allows LTN to make its reliability, availability and latency guarantees.

An interesting contrast in the data in the tables above is the difference between full-time channels and occasional-use traffic in terms of the percentage of rerouted feeds. At LTN, most of the occasional-use traffic we see is less than 6 hours in duration. There are exceptions, like multi-day events, but they represent the minority of traffic. Internet congestion is lumpy, not evenly spread across ISPs, geographies or connections. Full-time traffic has a 100% guarantee of seeing all such events that occur across their primary path, while the probabilities are much lower for ad hoc traffic since it has a much shorter duration. Nevertheless, for high value content like sports, esports, concerts, summits, important breaking news or other critical events, the risk of serious disruption implied by the 8-9% reroute data is often too high.
High value, live and real-time content distribution has exacting requirements for consistency, reliability and delay. Guaranteed reliability requires an intelligent overlay network that can track, route and reroute flows over multiple carrier backbones in milliseconds to ensure delivery under any Internet conditions.

In fact, as the data shows, more than one reroute is often necessary to ensure proper delivery metrics. These requirements cannot be met by deploying smart boxes at the edge, connecting them to the Internet, and relying on Internet routing to get the traffic delivered across the network. Customers looking for high reliability alternatives to satellite transport need service providers to make the necessary infrastructure investment, including installing intelligence at data centers worldwide, purchasing hundreds of gigabits per second of bandwidth from multiple Tier 1 ISPs around the world and building a 24/7 NOC to manage each customer’s traffic individually—as LTN has already done.
Benefits of LTN Service

SLA guarantees for performance
LTN provides customers with the Internet-based video transport industry’s only SLA guarantees on reliability, availability and latency. Our patented and innovative DMR algorithms and RER protocols enable LTN to deliver guarantees to customers that are essential for high value content distribution—content that customers expect to be delivered on time, on spec and with consistent reliability.

Multiple levels of redundancy and resilience
The LTN solution includes multiple levels of redundancy in hardware, software, Internet last-mile connectivity and backbone routes, ensuring reliable delivery of our customers’ video feeds with no single point of failure anywhere in the end-to-end path.

Immunization against any single carrier’s failure
All LTN backbone network nodes are a) constantly and fully aware of the real-time state of every feed, regardless of whether or not they are on the primary path of that feed’s delivery; and b) connected to multiple 10 Gbps Tier 1 carrier backbones. This combination ensures that any single carrier’s service degradation or failure will result in DMR algorithms rapidly re-routing traffic over another carrier without interrupting the...
customer’s feed. Private fiber and MPLS networks are single-carrier networks, with the attendant risk of failure in any single carrier.

**Universal access from anywhere in the world**

Customers access LTN’s managed service via commercially-available Internet connectivity from any site anywhere in the world, enabling them to easily, rapidly and cost-effectively transmit or receive live and real-time video feeds under high performance and reliability SLA's.

**Highly scalable in number of channels and destinations per channel**

LTN’s infrastructure is built with the capacity to transmit thousands of simultaneous feeds to tens of thousands of sites. It is also architected to continue to grow and scale beyond that, taking advantage of a distributed system of data center capacity and bandwidth supported by robust messaging systems, protocols and routing algorithms.

**Fully managed service**

LTN supports its innovative network solution with a fully managed service, including a 24/7 Network Operations Center (NOC) that is staffed by highly trained technical personnel who are able to monitor, isolate, diagnose and fix any issues on the LTN network affecting a customer’s feed and available as a 24/7 help desk for our customers.

**High visibility monitoring tools to control the performance of flows**

LTN has developed a large portfolio of monitoring and diagnosis tools that allow our NOC, as well as our customers, to have an unprecedented level of visibility and control over the performance of each individual feed on the LTN network. This includes
monitoring video equipment on the customer’s premise, LTN appliances, Internet links, the end-to-end path over the LTN network and the metrics and performance of the feed at the received site. LTN’s NOC spends the majority of its time solving issues outside its own network domain. The diagram below is a screenshot from LTN’s last mile Internet monitoring tool that gives its NOC personnel, as well as customers, visual and metrics-based feedback on the performance of the underlying Internet link and allows LTN to work with the ISP to resolve any issues on their own infrastructure.

Standards-compliant encoding and transport

LTN technology is fully compliant with broadcast standards for transmission such as MPEG-TS streams (ISO/IEC standard 13818-1), use of MPEG2 (ITU-T Rec. H.262), MPEG4/AVC (ISO/IEC 14496-10 and ITU H.264) and HEVC (ITU H.265) video compression, and interoperates with all standard broadcast video equipment. This interoperability enables customers to connect their traffic to the LTN network in an open and flexible way without any concerns about proprietary walled gardens. Customers also have the freedom to choose any encoding equipment or format, as long as it is MPEG-TS compliant.

Secure and protected flows

LTN provides secure and protected feeds over its network. LTN has the ability to encrypt flows which can only be decrypted by authorized receiving appliances. The LTN content protection uses standard, well-understood and respected cryptographic algorithms such as AES-128 for encryption and RSA-2048 for public-private keys. LTN fully manages authorization and authentication of each channel to ensure that customers
control which receivers are allowed to receive specific channels, giving them dynamic control of their content’s security. Additionally, LTN’s backbone nodes are located in highly secure data centers with secure entry, back-up power and redundant HVAC facilities.

**LTN project management process**

LTN has accumulated substantial experience over the last decade in configuring, installing, activating and supporting customer feeds in networks consisting of hundreds of locations. This mature process ensures timely activation of new channels or new sites in a reliable, consistent and repeatable manner.

**Flexible and cost-effective pricing model**

Many of our customers use LTN not simply as a substitute for existing fiber or satellite infrastructure, but as a provider of next-generation video transport technology and service that enables new business models. LTN’s pricing is not just more cost-effective than traditional transport services, but it also has the flexibility to enable successful customer business models in a world where content customization and regionalization is critical to business growth. As one example, our pricing models enable customers to send multiple geography, device or market-specific versions of their channels with a cost that is proportional to the number of receivers rather than to the number of versions of the channels being sent. Our business success is built on our customers’ success.
The LTN Advantage

LTN was created in 2008 by three co-founders who have been working in the IP and Internet world collectively for nearly a century. Malik Khan headed the division at Motorola that built the first commercially deployed cable modems and CMTS systems and spurred the advent of residential broadband Internet access. Yousef Javadi was head of Sprint International and ran all of Sprint’s Global entities outside the US including IP networking, hosting, and other infrastructure. Professor Yair Amir was, until recently, the Chairman of the Computer Science Department at the Johns Hopkins University and is recognized as one of the leading researchers in Large IP Systems Architecture. This founding team assembled a uniquely qualified research, development, operations and customer solutions team at LTN to focus on creating the industry’s first terrestrial IP network for live video and audio transport at a global scale.

1 - Participation by Dr. Amir as an officer does not constitute or imply endorsement by Johns Hopkins University.
LTN was founded on a vision that the future of video content distribution would be over the Internet, using new technology to build an overlay network on top of the Internet through which high quality content could be distributed anywhere in the world, to any device a consumer wished to use, quickly, easily, consistently, reliably and with high quality. LTN has created the essential technology to fulfill this vision and has patents granted in network architecture, algorithms for lossless traffic routing around Internet issues and protocols to recover lost or out-of-order packets. LTN’s innovation has resulted in a network that achieves both extremely high reliability and very low delay to transport live and real-time audio and video traffic anywhere in the world. Importantly, LTN’s network treats each customer’s program or event as an individual flow that is tracked, monitored and managed end-to-end, allowing us to control the routing of that flow in real time.

Over the past decade, we have worked with some of the largest media companies in the world in news, sports, and entertainment program acquisition and distribution. Customers like Disney, ABC, ESPN, CBS, NBC, CNBC, MSNBC, Fox, Sinclair, Turner, CNN and many others have taught us what features and functions are needed by them to transition to the future of live television programming and pursue new live-event business models and distribution strategies. Since LTN’s core strength is our research and operations capabilities, and since we own the technology with which we create our network and our fully managed service, we have been able to provide a bridge to the future to our customers.

We would welcome the opportunity to work with you and add you to our growing list of connected companies and sites.
Contact Us

Technological innovation is driving growth and creating new opportunities for the broadcast and media industry. New competitors are vying to capture viewers, leveraging new technologies in unique and creative ways. If you are ready to begin exploring how to reach a greater global audience, connect to media partners around the world and achieve new, more efficient and effective workflows, LTN is your guide.

Connect with us at sales@ltnglobal.com, or call us at +1.301.363.1001.