Core Insights

From the experts at The Broadcast Bridge.

Internet Contribution For Broadcasters

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Introduction

by Tony Orme - Editor at The Broadcast Bridge.

What is the internet? Who is the internet? Where is the internet? These are the first three questions on the tip of every engineers and technologist's lips. Before we can ever possibly hope to work with internet technology, we must be able to answer these three basic questions.

Broadcast infrastructures based on SDI and AES used fixed leased lines for video and audio distribution and contribution. Often provided by local telcos, these circuits benefited from service level agreements that nailed down latency, bandwidth, and reliability. A whole industry support system made sure they worked reliably and often a single point of contact was available 24/7 to help rectify problems should they occur.

The price we paid for such services was massive planning, installation, and rental costs with little flexibility.

Internet circuits are highly flexible and can easily reach most parts of the world with little intervention from the user. Their costs are moderate but the challenge we have when using them is that meaningful end-to-end service level agreements are often lacking, and sometimes non-existent. But they have the potential to revolutionize broadcast contribution and delivery.

Understanding the basic principles of interconnectivity is critical. However, the technology is only part of the story as contractual agreements between ISPs and intermediaries are often cloaked in secrecy due to the commercial sensitivity of the service providers arrangements.

An ISPs quality is not only based on the final-mile connectivity, but also their ability to reliably reach other parts of the world based on their commercial agreements. Rerouting and fault resilience all play a part in this resulting in multiple tiers of service provider that deliver data based on their position within the network structure.

The internet is not one organization. There are certainly elements that are administered by a governing body, such as IANA for the issuing of public IP addresses, but the internet in general is a massive collection of telcos, ISPs and other service providers that collaborate to deliver internet connectivity throughout most of the world.

Border Gateway Protocol (BGP) and Autonomous Systems (AS) are two of the most important features of the internet that guarantee individual companies and organizations can exchange the user's data between them. The hierarchical nature of IP with its transport stream agnostic characteristics, means that internet companies do not need to be concerned with the data they are transferring.

Data and transport stream agnostic distribution is both the internet's greatest strength and weakness. Without them, the internet would not be as popular as it is today as service providers would find it very difficult to collaboratively exchange data without further resource hungry processing. But a lack of awareness of the type of data being transferred leads to many compromises and makes distribution of video and audio a challenge. Hence the reason CDNs have been so popular in recent years as they focus on the unique characteristic's broadcasters demand from video and audio networks.

Broadcasters are used to using custom SLAs that deliver exactly what they want and when they want, but at a massive cost in terms of price and flexibility. Using the internet presents many new challenges as we must fit in with an already established system. But we should remember, the more we try and interfere and tweak this system, the more likely we are to increase costs and reduce flexibility.

Part 1 - Overview

IP is empowering broadcasters the world over to improve flexibility, scalability and resilience. We often describe the internet in "fluffy cloud" terms, but to truly leverage its capabilities, broadcasters must now dig into the detail of its operation.

To understand the power of the internet and its ability to provide ad-hoc connectivity, it's worth thinking about how we would have sent video and audio across the planet and interacted with other international broadcasters.

Video and audio are relentlessly hungry for data bandwidth. The continuous nature of video frames and audio samples stretch any network leading us to use point-to-point delivery for much of our media distribution and contribution needs.

Historically Static

Satellite links and dedicated lines have been at the core of media transfer for nearly fifty years. Although this technology has served us well, and continues to do so, it's proved incredibly expensive and relatively inflexible. Yes, we have mobile satellite uplink trucks, but the latency limitations and line-of-site requirements are making this technology difficult to use.

With a single hop up-down link in one direction only, latencies of 250ms for a geo-stationary orbit satellite are a reality of physics, doubling to over 500ms for full duplex. Although atmospheric conditions rarely affect satellite links, they do occur and there is little scope for diverse routing for a single truck.

Broadcast specific fixed lines may be low in latency, but the custom nature for SDI and AES delivery are now making them seriously uneconomical, especially when we consider their lack of flexibility and long installation times.

Internet Topology

The internet is a whole series of interconnected networks from many different telcos and service providers who communicate through the Border Gateway Protocol (BGP) to exchange routing information. Network providers have no knowledge of the internal workings of each other and rely on the BGP to know where to route IP packets between them.

BGP is the core protocol that allows telcos, otherwise known as Autonomous Systems (AS), to communicate with each other allowing the routing of IP packets throughout the world. It's the application of the BGP that and the data transfer between ASes that is effectively the core of the internet and facilitates seamless exchange of data.

An AS is a complete administrative domain that contains anything from a single private network to multiple private networks of differing physical connectivity. It is the interconnectivity of the ASes using the BGP routing protocol that is in effect the internet.

Assuming an AS describes a single telco or service provider, then the internet is made of many such vendors. Users connect through their ISP (Internet Service Provider), which in turn is likely to be an AS, but then connects to other ASes thus giving access to servers around the world. The BGP advertises its connections to other connected ASes so that they can

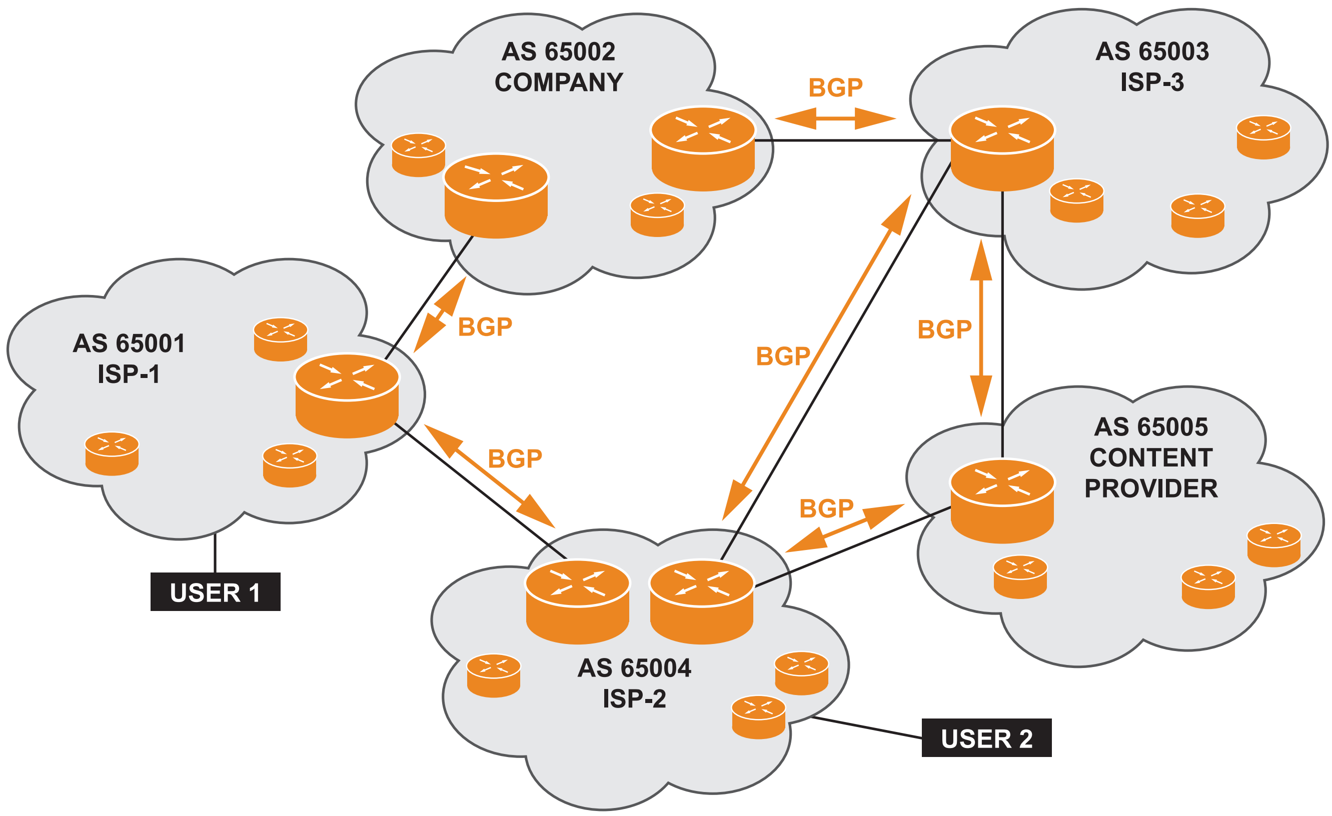


Figure 1 – The internet is an international group of collaborating ASes exchanging routing information through BGP, this in turn allows them to send user requests and responses around the world. Here, user-1 will access the internet via ISP-1 and may want to exchange data with ISP-2, the shortest route is from AS65001 to AS65004, however, if this fails, there are many other routes available but using them will increase latency. A deep knowledge of the internet connectivity is required to keep latency low and data throughput high.

route packets between servers and clients. Furthermore, BGP allows policies to be applied to the routes so that they can be classified in terms of priority and application. For example, commercial connectivity requiring priority throughput could be give preference over traffic for home use.

Centralized Efficiency

Critically, BGP is decentralized allowing each AS to act autonomously and only advertise the routes of interest to other telcos and service providers, thus empowering telcos to determine their own architectures and policies for their geographic location without having to share this commercially confidential information with others.

One of the reasons the internet, and IP in general, is so successful is that IP is hardware agnostic. It doesn't care whether it's being transported over WiFi, ethernet or HDLC. IP packets are encapsulated in a low-level transport protocol which does not change the IP packet in anyway, thus leaving the packet to be delivered to the end destination without being changed on route by the transport mechanism.

Another important aspect of IP is that it is packet switched, as opposed to the circuit switched nature of SDI and AES circuits. Not only does this facilitate incredible flexibility, scalability and resilience, but IP routers and their supporting protocols, remove the switching decisions from an overall management system and allow them to happen at the transport layer and distributed network level.

For the internet to operate as reliably as it does, not needing an overarching management system controlled by one entity is incredibly powerful. There must be agreement between different international telcos on the version of BGP they use, the IP addressing schemes they adopt and the AS addressing numbers used but allowing the packet routing to occur at the transport level both encourages autonomy and collaboration. In fact, without this simultaneous autonomy and collaboration, it's unlikely the internet would exist in the manner it does today.

Interconnected ASes

We connect to the internet through ISPs, which can be subsets of ASes or ASes in their own right, depending on the size of the telco. For example, a smaller telco may only be regional based and will connect to a global AS to gain the connectivity to the rest of the world. Or it may connect to multiple ASes which in turn provide international connectivity. Internet exchanges are gaining in popularity as they act as intermediaries to facilitate international connectivity of ASes and help improve speed and reduce latency.

The end goal for telcos is to increase the number of clients they connect to, keep latency low and reliability high. The more connectivity a telco has to the wider network of other ASes, then the easier they can achieve low latency and high reliability. The diverse number of connections to different telcos further encourages reliability as networks can automatically determine alternative routes if one connection fails.

Having a distributed network with seamless international connectivity of multiple telcos is the power of the internet and provides broadcasters with incredible opportunity for provision of contribution circuits.

There's Always A Cost

It's important to remember that the internet is not "free", there are huge costs associated with the infrastructure expansion. Just think how much it costs to lay armor protected waterproof cable under the oceans, and that's before we start considering the high-end routers needed to connect them together.

Although broadcasters still have an unquenchable thirst for data bandwidth, and this is unlikely to change in the imminent future, accessibility to the internet through highspeed fiber is much easier now than it's ever been. Telcos are increasing their connectivity points, whether at sports stadiums or into cloud datacenters and this is providing much easier access for broadcasters.

Part 2 - Applications

Let's consider the broadcast applications available and what it means to "connect to the internet".

Advertising routes through the Border Gateway Protocol (BGP) for multiple ASes (Autonomous Systems) is key for distribution and reliable delivery of IP packets throughout the internet. The combination of a telcos autonomy combined with the collaboration provided through BGP delivers the power of the internet.

However, it's difficult for ISPs to provide SLAs to guarantee bandwidth and latency with a generic service, and media distribution is quite unique compared to the client-server websites and file transfer that the internet often deals with.

So, why can a broadcaster not just bypass the telco and connect directly to the internet backbone?

ISP Provision

The simple answer is that some do by becoming their own ISP, even if they are their only client. To be a member of the internet club, that is be an ISP or part of the connectivity infrastructure such as an internet exchange, you need to have your own set of dedicated IP addresses, be able to exchange BGP routing information and have your own unique AS numbers, and then you can send the actual data.

Although this sounds relatively straight forward, there is a whole load of detail that is quickly glossed over in this suggestion making the possibility of becoming an ISP for most broadcasters an unviable option. For example, we need to consider the metrics for maintaining high data throughput and low latency. And resilience is key as a connection's bandwidth can be congested, compromised or even lost completely. Having an abundance of other ASes to connect to is critical so that diverse routings can be provisioned.

Another method for using the internet for media contribution is to use a service provider that understands media and has many relationships with other ASes, and is able to monitor the metrics at a deep level to maintain high data throughput with low latency.

Relationships Are Key

Relationships with other ASes shouldn't be underestimated as these are the key to providing resilience, reliable connectivity and low latency. For example, if a routing via AS-1 fails, then another routing must be quickly established. If a broadcaster is using a telco with a limited number of AS connections, then the resilience is going to be limited and the overall experience will be quite poor.

We often speak of the internet as being resilient, but this resilience is not a coincidence, it must be planned and relationships with other ASes must be maintained before we even consider the exchange of the media data. But as the number of AS connections increases, then so does the complexity of the telcos own network along with its connectivity to others. And at the end of the day these networks need a lot of talented people to operate and maintain them.

This complexity does work to a broadcaster's advantage as a "media streaming" friendly service provider will understand the difficulty of transferring video and audio with the minimum of latency. The internet was originally designed to be transactional in its operation through the client-server model. This is far away from the constant data flows video and audio demand.

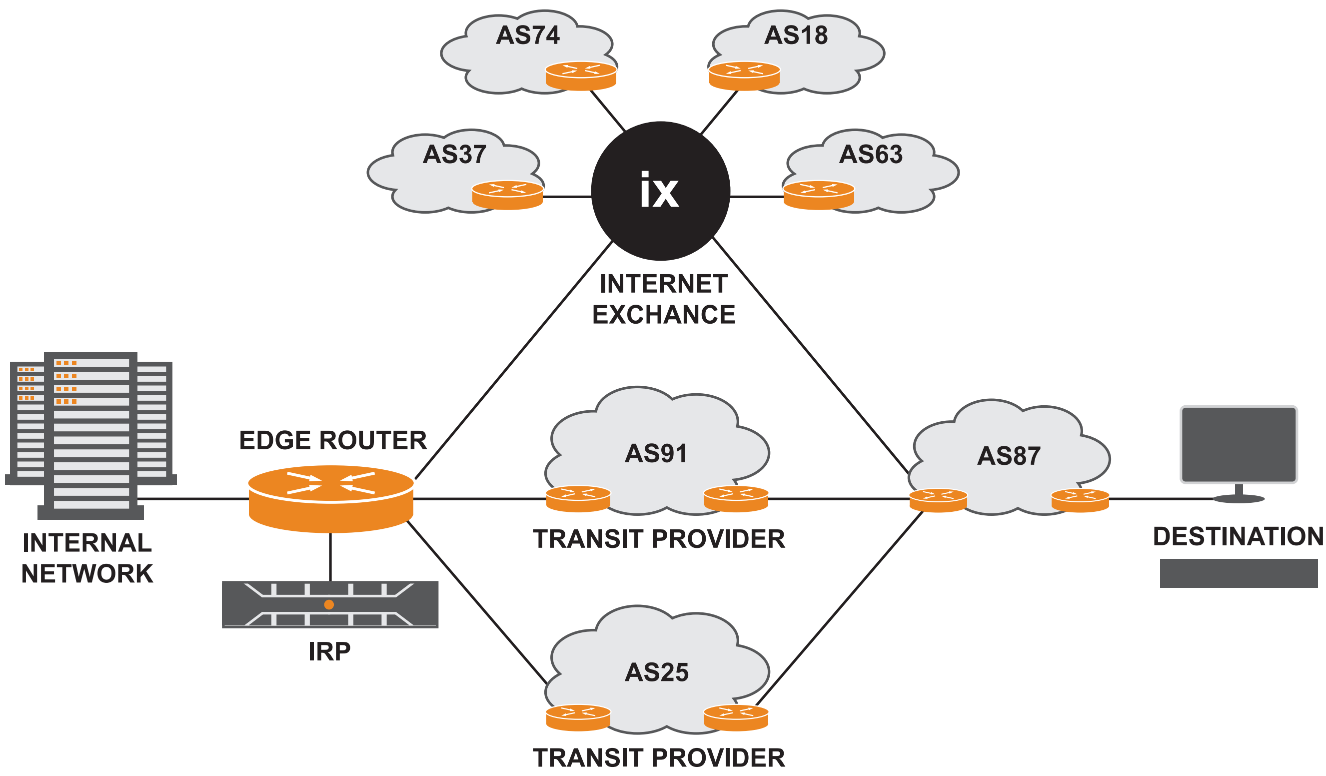


Figure 1 – Internet Exchanges provide an alternative and high-speed method of connectivity to other ASes around the world. Here, the transit provider can be bypassed using the IXP if latency or data throughput issues were to occur. Also, the IXP increases the number of potential ASes that a telco can access.

Consequently, not only do the engineers need to understand video and audio, but they also need to be able to apply their network analysis tools to the vagaries of broadcast television.

A service provider may be able to negotiate with other ASes the most optimal routing for a specific media stream. This is particularly important when broadcasters need contribution services for productions such as outside broadcasts, especially when working across country boundaries.

IXP Improvements

Internet exchanges (IXP) are further improving the resilience and efficiency of the internet. By having telcos, content delivery providers and mobile phone operators all connected to an IXP, the ability to exchange data reliably between them with the minimum of latency is greatly improved. But just like the connectivity between ASes, there is a lot of collaboration between often competing businesses, so a great deal of trust has been built in making the internet exchanges operate efficiently.

IXP efficiencies are gained as ISPs may take the fastest route based on their agreements with other ASes, but this may not always be the fastest physical route. For example, if a user in Oxford connects to a server in Cambridge, and the Oxford user's ISP only has an AS connection via London, then the shortest physical route is not used (Oxford to Cambridge) as the routing takes place via London. This situation is based purely on the fact that the users Oxford ISP doesn't have a direct relationship with a Cambridge ISP so must go via the relationship it has with the London ISP.

It's almost impossible for any ISP to have relationships with all other ISPs and ASes in every country throughout the world so the IXP provides much faster and convenient connectivity. Also, IXPs often have international connectivity to other IXPs so that ASes can achieve better connectivity across the globe, further reducing latency and improving the important round-trip time of TCP packets.

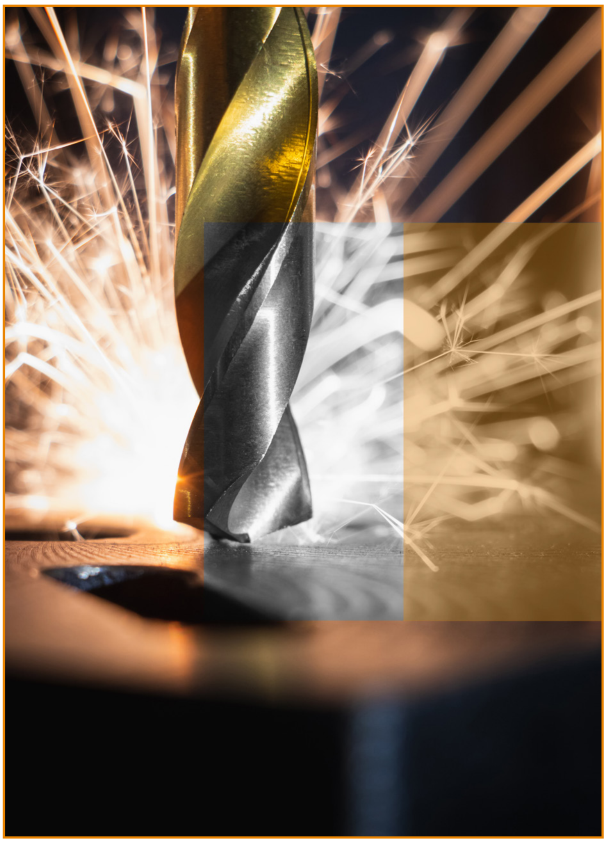
Essential Monitoring

Being able to provide monitoring at critical points through a media streams' journey is key for broadcasters looking to use the internet as a contribution service. Due to the complexity and number of service providers involved in the distribution, using a network provider that has this level of visibility will help enormously.

IP infrastructures in general provide a massive opportunity for scalability. For broadcast applications it's reasonable to assume that the final mile uses a variation of fiber to deliver bandwidth far in excess of their requirements, even for an outside broadcast with full duplex data paths. Once the data reaches the service providers network, extra bandwidth can be supplied as required. Full monitoring is also provided so any network issues can be detected quickly and dealt with appropriately.

Provision of contribution circuits over the internet is a relatively new phenomena for broadcasters. However, combined with a media-friendly network provider, the internet is proving itself to be a formidable alternative to fixed point-to-point lines, especially when we consider the flexibility and scalability the internet provides.

Media-friendly service providers not only deliver low latency and high bandwidth connectivity for broadcasters, but they also facilitate deep levels of monitoring and a knowledge of the whole internet to achieve reliable service delivery.



Part 3 - Why Carriage Matters To Live Internet Video Delivery

by Adrian Pennington

On the internet, congestion and latency is added at the points at which carriers connect to each other. Understanding this will help you design a better quality video service, says Bernhard Pusch, Head of Global Internet Strategy at Telstra Corporation.

Using the internet to distribute live content has exploded. Internet delivery is cast as a less expensive means of transporting more content to consumers to watch on the device of their choice. Well in train before 2020, the past year has sent the need to connect events at venues using remote links into overdrive. More and more major sports franchises are moving direct to consumer over the internet (OTT) with broadcasters supplementing their over the air programme delivery with live streaming services.

The key issue with live video is the requirement (especially in professional environments) to ensure there is an uninterrupted feed. The lower cost of using unmanaged internet networks is often traded with the quality of the end product. Some broadcasters are still holding out against wholesale shift of live linear content to the internet in the belief that private lines are superior.

And it is hard to argue with that when you see the results of the buffering, delay and jitter which is all too common on live sports streams.

Typically, when running video point to point over a private network the broadcaster has control end to end. There's no need to perform a check sum if data is lost in transit as with an IP network. There are decades worth of confidence that the signal will be received on time, intact, in sync.

But the nature of internet architecture means you can never be 100 percent sure. On the internet, depending on which routes and providers you use, there are multiple sources of potential congestion. These are what typically cause problems with live video.

To mitigate this, you can add systems and protocols to the stream to ensure integrity on reception. This has the impact of adding delay which is exacerbated where the route between source and destination is a lengthy one. Even half a second latency is enough to cause concern for broadcasters especially if they compare the best efforts of the internet to a satellite relay.

That's why, when you design video over IP networks, it's important to understand how the internet works and where congestion and latency is inserted.

For most people the internet has the appearance of one homogenous cloud in which packets transit from one end to the other.

But the more deeply you peer into the topology the more you understand the complexities at play. For instance, there are certain carriers that only interconnect at particular points in the network. There are also certain carriers which will be overbooking their service.

Understanding Congestion

Digging into this further, you will find larger more professional carriers in the internet space selling 1Gig of internet capacity to customers and will allocate 1Gb of service in the network to carry the client. On the other hand, some lower cost, lower speed operators might overbook by, for example, servicing 2G of capacity for 1Gig on the network. This leads to traffic congestion.

Congestion and latency rarely occurs within a carrier's network. The bottleneck is between carriers, the points at which traffic is handed over to another carrier. Congestion is further complicated at these interconnect (peering) points by issues unrelated to technology and all to do with local competition and political rivalry.

In some regions and especially in APAC, carriers will only interconnect with each other at certain points, sometimes at considerable distance from their home market.

Understanding The Politics Of The Internet

Korean carriers for example will connect in Japan. Taiwanese carriers might connect in Japan and Hong Kong. In some cases, carriers will only interconnect on the West Coast of the U.S. Their primary purpose is to keep rival international carriers out of their home networks and force OTTs to pay to connect locally (thereby providing best performance) to their networks.

None of this is obvious to the casual observer but it has major implications downstream. You might think you have a signal going the shortest route from A to B when in fact it is yo-yoing from A to C and D to B and will consequently take much longer than you think.

In the case of the major online content providers like Netflix or Amazon, the likelihood is that their consumers will enjoy a good experience at home. The reason is that Netflix or Amazon servers are almost certain to be connected to the same carrier that brings consumers their local home broadband. Internet Service Providers are going to want to make sure that Netflix and Amazon subscribers don't receive a poor experience since the comeback is likely to be on them. It is the service provider not the content owner who gets the customer service call or reputational damage on social media when content goes down.

In the case of live media is it the broadcaster not the broadband provider who will get the blame. What's more, content provision of live events is often not in-country but intra-country with feeds bouncing between points of presence, with different carriers connecting at different and multiple points each adding potential latency.

Knowing where the interconnect points are and understanding the politics of the internet helps you to design networks and setup the right interconnections between the fixed network and the internet to give you optimal delivery.

When building networks for delivery over the internet it is important to bear in mind exactly where the source and destination are and combine that with knowledge about the structure of different carrier politics and congestion points in order to avoid them.

With careful design and understanding how the internet works, these issues can be largely mitigated (although not completely removed) enabling substantially cheaper solutions to be implemented for delivering video with acceptable performance.

All carriers are not the same. Some broadcasters may not care if a carrier drops 20 percent of packets or if the latency is on the high side because they are getting a cheaper service. Other carries will always give the best quality service. That's something to bear in mind.

Telstra Internet Delivery Network

The Telstra Internet Delivery Network provides a gateway from 'on-network' media rights-holders to 'off-network' media buyers, using Telstra's high-capacity Internet peering arrangements and cloud infrastructure.

Each gateway is located strategically in-region where Telstra provides its own Global Internet access and peering arrangements with Tier1 Telcos and content providers. The Telstra Internet Gateway will encapsulate the contribution feeds and send them via its own Global Internet Direct access to the Broadcasters. Managed by broadcast media and technology experts at Telstra Broadcast Services, they will offer the possibility takers to select appropriate transport protocols. Examples include; Zixi, SRT, RTMP, UDP/RTP with FEC, RIST, and HLS.

A full managed end-to-end network with the flexibility to manage large scale media operations and accommodates unpredictable latency, network hitter, packet loss and network congestion.

Internet delivery will only be the last mile connection to the customer. Telstra is choosing this solution as major Tier 1 Telco in the world, we have high-capacity Internet peering arrangements with local Telcos and content providers. By leveraging its direct peering links Telstra can semi-manage the streams via its Internet backbones and monitor the non-congested paths to provide a secure streaming experience.

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