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# Cloud Ingest of Live Video – An open approach to RIST, SRT and retransmission protocols

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**White Paper**

As cloud production becomes an integral part of broadcasters' live workflows, the corresponding cloud infrastructure becomes an integral part of the media transport network. Cloud infrastructure providers, often public in nature, are accessible either through the public Internet or through leased lines. In both these cases, broadcasters are challenged with the quality of the transport often not being sufficient for high-end broadcast applications. While the established approach to overcome this challenge is retransmission technology, there is today a plethora of options to choose from. This paper aims to discuss the pros and cons of these different options and why today there is no silver bullet solution.

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## INTRODUCTION

Over the past decade, providers of public cloud infrastructure have established themselves as a generalized compute platform for a large number of applications with media being one of them. The advantages are plentiful with a more flexible cost model and a higher degree of reusability and resilience. To reap the benefits of the cloud transition, media functions are moving away from FPGA and ASIC architectures for most general-purpose tasks, enabling the cloud to become the de-facto execution environment also for high-end media applications. Due to the stringent requirements of live production, the natural starting point for broadcasters to fully utilize these benefits is within file-based workflows, having left most live workflows to dedicated media equipment on-premise.

Simultaneously, media networks are in a transition towards IP and Ethernet. However, while delivering on these stringent requirements for live media is certainly achievable in Local Area Network (LAN) environments, meeting those same requirements in a Wide Area Network (WAN) setting, and even more so in shared WAN networks, is a lot more challenging.

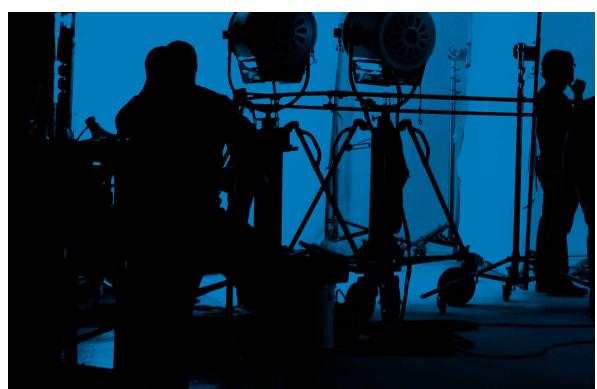
To solve many of these challenges, SMPTE's ST 2110 suite describes how to build IP networks for media services. Starting in-studio and driven by a promise of lower cost and higher flexibility, standardizing on IP as a bearer protocol for high-end media also implies better interoperability with datacenters and public cloud environments. Consequently, there is now a new challenge that needs solving in terms of high-end media services over WANs.

However, as SMPTE is fully occupied with solving the in-studio challenge for live tier 1 productions, other solutions have emerged for lower tier content as a direct consequence of cost pressure.

At 10 years in the making, what is generally referred to as retransmission technology, or Adaptive Repeat reQuest (ARQ), has proven itself many times over and is by now an established part of the tier 2/3 production ecosystem.

While the introduction of retransmission started as a way of delivering broadcast quality media connectivity over lossy infrastructures at a low price point, it now boosts functionality ranging from simple point-to-point connections, to point-to-multipoint, load balancing across Internet Service Providers (ISPs), seamless switching, and more.

While in-studio adoption of IP technology has been reasonably slow due to the inherent difficulties in getting vendors and broadcasters to agree on a common framework, the tier 2 and 3 markets instead turned to proprietary solutions leading to multiple parallel protocols and ecosystems as a consequence. And even while solutions with a "standards-oriented approach", such as the Video Services Forums (VSFs), have emerged in recent years, adoption is bound to be slower due to the investments already made by broadcasters in existing proprietary ecosystems.



## CLOUD RESOURCES FOR LIVE MEDIA

Historically, media equipment has been built on FPGA and ASICs based architectures. This has been necessary to cater for the extremely rigid requirements demanded by professional media production. As cloud makes its way into media production, it is natural to ask what the consequence of moving a general-purpose execution environment versus a specialized one actually is. While the differences are many, from a technology perspective two of the key ones are accuracy and dynamicity. Accuracy from the point of being able to guarantee that a task is executed at a precise and exact point in time. For many applications this may not be an issue, but for some, such as synchronization and monitoring it can be challenging. As cloud technology evolves it is now possible to utilize Graphic Processing Units (GPUs) and even FPGAs to accelerate functions that require a higher degree of accuracy. This also helps in other tasks, such as being able to provide real-time encoding and transcoding operations in cloud environments. Encoding and transcoding in cloud is not new of course and has been possible for some time using the simple method of overprovisioning CPU cycles. But by being able to use dedicated accelerators for these tasks, the economy of scale changes significantly.

This also ties into the other major upsides of cloud, dynamicity and flexibility. As historically dimensioning the entire production environment for peak utilization was financially challenging, it is now possible to dimension it for average use, while leveraging cloud resources for peak usage, providing a more elastic cost model.

### I. Two types of cloud realizations

While we often talk about the cloud in terms of the large public infrastructure providers, a cloud infrastructure doesn't have to be public. It may equally well be a self-built datacenter, which for example could be better suited at handling uncompressed workflows. Even though handling connectivity within a specific datacenter could be challenging in itself, it is still fully within the control of the owner of that datacenter. With public cloud environments however, this is typically not the case. A video stream as an example often traverses a number of hops outside of the datacenter providers operational responsibility. Therefore, the main focus of this paper is on connectivity to public cloud providers although granted the concepts can be applied to private datacenters as well, if required.



# RETRANSMISSION TECHNOLOGY

Before diving head first into the technology, let's first look at what challenges it is trying to solve.

## II. Requirements from a video perspective

Looking at live broadcast video and the requirements that has on the underlying transport network, there are two fundamental properties that are specifically applicable to retransmission technology.

- **Loss sensitivity:** Mostly related to the properties of the embedded codec, loss can be challenging for streaming media. In MPEG, as an example, losing an I-Frame means worst case several seconds of outage depending on the GOP length.

- **Latency sensitivity:** While this depends on the application itself, latency could end up being a deal breaker for using retransmission technology. Having said that, in most cases the codec delay is the large overshadowing factor for the end-to-end chain.

From a retransmission technology perspective, these are the two parameters that are constantly balanced against each other.

If avoiding loss is the primary concern, increase latency. If low latency is key, reduce latency at the cost of increased risk of impact to the video quality.

For retransmission technology itself there are also a number of other factors at play such as packet pacing, bandwidth variation, etc. While most of these challenges have also been solved by modern day solutions, these are outside the scope of this paper.

## III. Technology

Within media, retransmission technology, or ARQ, is often described as a groundbreaking solution to a media problem. From a historical perspective though, retransmission is a fundamental part of TCP, the most widely

used protocol for IP delivery and a part of the TCP/IP stack. Ultimately providing much needed properties such as guaranteed delivery and fairness for users. Its sibling, UDP, is instead a fire & forget type protocol which is well suited for streaming applications with high throughput and low latency. Without going into too much detail, what is generally regarded as retransmission technology within media is a way to marry the two, to create a solution that is ideal for live streaming broadcast quality video over lossy networks.

Table 1 below lists the three approaches and their respective pros and cons for live streaming media.

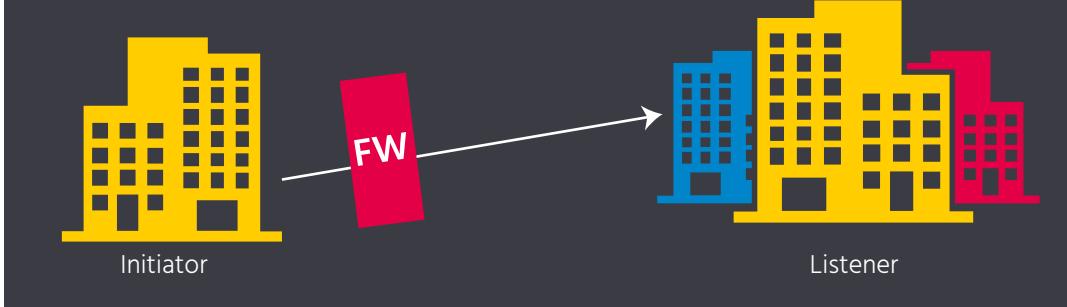
Implementation	Advantages	Disadvantages	Examples of implementations
TCP	+ Fairness + Guaranteed delivery	- May lead to buffering at receiver - Limited control of latency	HLS MPEG-DASH
UDP	+ High throughput + Low latency	- Does not handle lost packets	RTP RTMP
ARQ	+ High throughput + Guaranteed delivery within window	- Latency higher <i>(but often fixed)</i>	Zixi SRT RIST LRT

TABLE 1: COMPARISON OF STREAMING PROTOCOLS

Of course, the information in Table 1 is assuming a somewhat lossy transport. In an ideal transport network, there would essentially be little difference between the three.

Another key concept of retransmission is the control plane establishments. Due to the nature of the environment this technology is used in, firewalls are rather the rule than the exception. To overcome this challenge, most solutions introduce what is often called a push/pull or caller/listener concept. It is based on the fundamental concept that firewalls typically pass traffic outbound but block inbound. This means, that the device, or function, initiating the video channel should be behind the firewall, whereas the listener not behind a firewall.

FIGURE 1: FIREWALL AT SENDER



If both sides are behind a firewall traffic can still be passed, however port-forwarding is required.

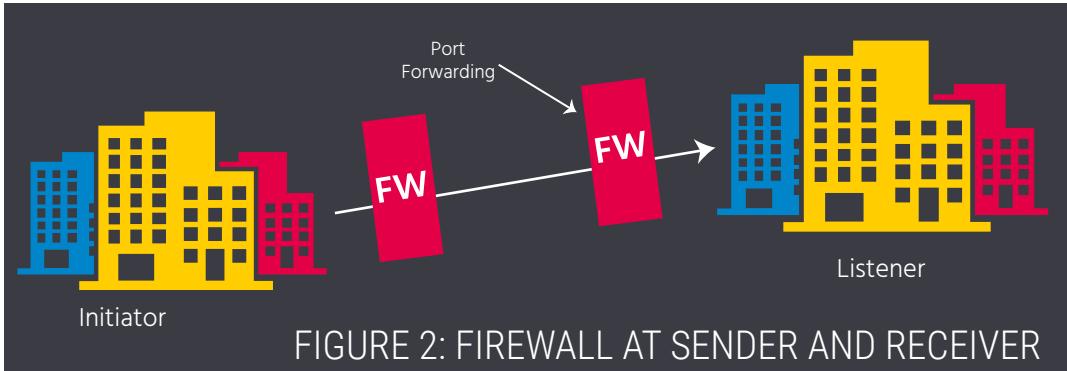
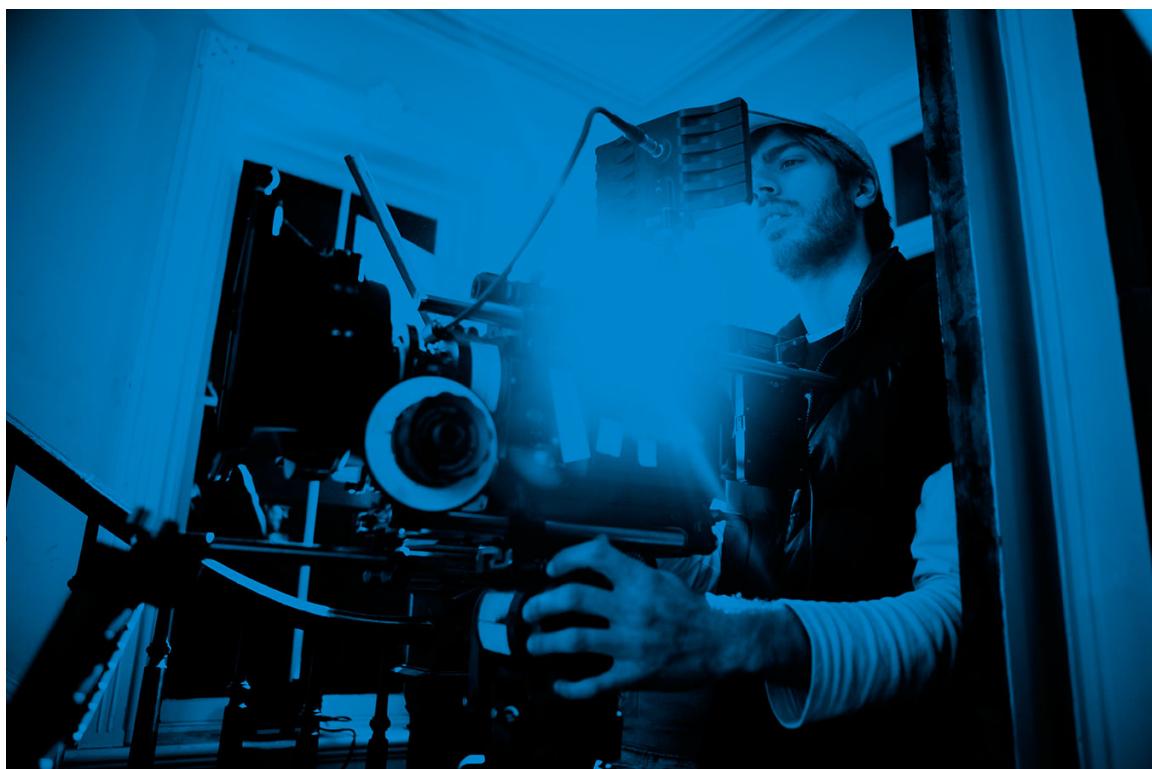


FIGURE 2: FIREWALL AT SENDER AND RECEIVER

The caller/listener concept is fundamental part of the ARQ establishment and provides a practical solution for most use cases.

Also, it is worth to note that retransmission technology is not the only way to improve quality over lossy links, there are also other methods such as Forward Error Correction (FEC) that can also be combined with retransmission. However that discussion is outside the scope of this paper.



## IMPLEMENTATIONS, AN OVERVIEW

Due to the availability of open source options, but more importantly because retransmission technology can easily be implemented in software, the number of vendors in the Internet contribution space is staggering with new entrants continuously making its way in the market. While fundamentally all these are based on the concept of retransmission in one form or another, the broadcast networking side of the market has three implementations that warrant a closer look. These have been chosen because of either their reach and large eco systems, or their openness in nature.

The three ones being explored in this article are Zixi, Secure Reliable Transport (SRT) and Reliable Internet Streaming Transport (RIST).

### IV. Zixi

Having been early into the market, Zixi has a strong field-proven implementation that in addition to standard ARQ also supports video encryption, ARQ with FEC, link bonding, primary and secondary backups and hitless mode.

The Zixi protocol is also integrated into a large number of vendor equipment ranging from encoders and decoders to cameras [1].

### V. Secure Reliable Transport (SRT)

Originally created by Haivision, SRT made a big splash in 2017 when the SRT Alliance was formed and through that an open-source publication of the SRT source code. With a strong team of backers (210+ members at the time of writing [2]), SRT has gained a large footprint in a relatively short amount of time.

Besides being a free, open source alternative, SRT now comes pre-integrated into everything from GStreamer to VLC.

This makes it simple to verify connectivity without costly hardware or software solutions. From a technology standpoint, SRT supports ARQ, video encryption and a variety of statistics [3].

### VI. Reliable Internet Streaming Transport (RIST)

Perhaps the closest thing to an actual standard is VSFs RIST, or TR-06. The RIST technical recommendation has been agreed upon through a standardization-like process and already has more than 30 supporting members [4] and growing rapidly. Given that this is the only community-developed open solution to date, it is reasonable to believe RIST will be a mandatory requirement from many broadcasters going forward.

In addition, while the RIST Forum and the RIST activity group have a fairly aggressive roadmap, proprietary solutions will likely be superior for niche use cases, at least in the short-term.

With the initial release (TR-06-1) RIST supports a simpler but highly important feature set, including packet loss recover and bonding (optional). In addition, RIST also allows for interoperability with non-RIST receivers by running in an RTP-only mode, effectively making it compatible with SMPTE 2022-1 and SMPTE 2022-2 receivers. It is also worthy to note that given the experience involved in drafting the specifications, the RIST work group is moving forward quickly and alluding to future functionality such as video encryption, VPN tunneling, NAT traversal, Null Packet Suppression and Adjustable Bitrate Encoding [5]. Many of these already schedule for ratification in 2019.

Similar to SRT, RIST already see a support base in the open source software community, with support in VLC and Gstreamer.

## VII. Technology comparison

To better try to understand the capabilities of these three candidates, the table below summarizes their current capabilities.

Protocol	Firewall Traversal	FEC Support	Encryption	Path Protection	Null packet compression
SRT	Yes, both sides	No (planned)	Yes, AES 128/256	No (SMPTE 2022-7 planned)	Yes
RIST	Yes, sender only (both planned)	Yes, SMPTE 2022-1	No (planned)	Yes (bonding optional)	No (planned)
ZIXI	Yes, both sides	Yes, proprietary content aware	Yes, AES 128/256 & DTLS	Yes, SMPTE 2022-7, bonding, primary/standby	Yes

TABLE 2: SUPPORTED FEATURES FOR RIST, SRT & ZIXI

Diving into these further we can see that while Zixi clearly has a head start when it comes to features, SRT and RIST are on a rapid trajectory to catch up. In addition, there is a certain bit on unfairness in comparing Zixi's full suite with the isolated protocol capabilities from RIST and SRT. As an example, many vendors may leverage the RIST standard for point-to-point transport, but build more advanced switching capabilities, such as SMPTE 2022-7, outside of the protocol stack.

While we do not have much detail about the actual implementation roadmap of SRT given that it depends on both submissions from the community and what Haivision themselves upstream to the code base, for RIST there is a clear transparent process in terms of what is planned.

At the current time of writing RIST main profile (TR-06-2) is set to include capabilities for encryption as well as firewall traversal and null packet compression at which time it will have everything required in terms of feature set for most applications. The publication of Main profile is not fully decided, but currently looking to be somewhere in the second half of 2019.

Understanding the feature set is a great way to understand the strengths and weaknesses of the different options, and ultimately the applications where they fit best. In addition, we have also conducted benchmarks to better understand

how these different protocols perform in real life. While there are clearly differences, it is hard to call them conclusive at this point due to a number of outliers in the results.

## VIII. Technology Conclusions

Looking at the technology alone, Zixi clearly boosts the highest number of features of the three providing more advanced redundancy features such as primary/backup and hitless mode. Still it is worthwhile to note, that while SRT is an open-source technology and free to use under the Mozilla Public License, Zixi is a paid solution. Also RIST exists in open-source form as an implementation under the Gstreamer framework. In addition, both RIST and SRT have their implementation specifications published in the open, making them relatively simple to implement.

## KEY USE CASES

The applications for retransmissions are of course many, ranging from contribution to distribution and exchange of video content. For the purposes of this paper, we are focusing on

- Cloud ingest of live video
- Content exchange

### IX. Cloud ingest of live video

Getting content to the cloud may sound simple. After all, most broadcasters have business connections to the Internet, where it connects to massive Internet core routers which are generally overprovisioned in nature. Still, much like the challenges SMPTE ST 2110 is facing in the WAN, the problem is not necessarily capacity. It is loss, jitter and latency. For loss, even the slightest percentage point leads to massive visual impact.

Consequently, major cloud providers are now introducing support for retransmission protocols to be able to ingest video into their media cloud services. This also goes hand in hand with costs for bandwidth finally coming down to price points where it starts to make sense for large scale distribution, in addition to just processing and contribution. While this is a technical paper in nature, it is impossible to discuss the options without understanding the path the two prominent cloud providers have chosen to take.

- **AWS Elemental MediaConnect:** Having introduced support for Zixi as an ingest protocol earlier in the year in addition to their previously published RTP/FEC option, AWS MediaConnect now provides all Zixi users the capability to reliably uplink their content to the AWS cloud service. Perhaps more interesting is that at the 2019 NAB Show, AWS also announced plans to add support for RIST as an ingest protocol, effectively widening the ingest capable customer base to any customer with a RIST capable device.

- **Microsoft Azure Media Services:**

Microsoft went a different route when they in 2019 announced support for the SRT [7] protocol, making SRT an ingest option alongside RTMP. Since then, Haivision has also launched their SRTHub offering on top of Azure, further strengthening their commitment to the SRT ecosystem

Announced support for the SRT [7] protocol making SRT an ingest option alongside RTMP.

It is also worth noting that while some cloud providers support direct connectivity leased lines, experience shows that quality is often not good enough to meet the stringent requirements of professional media without any quality enhancing technology anyway.

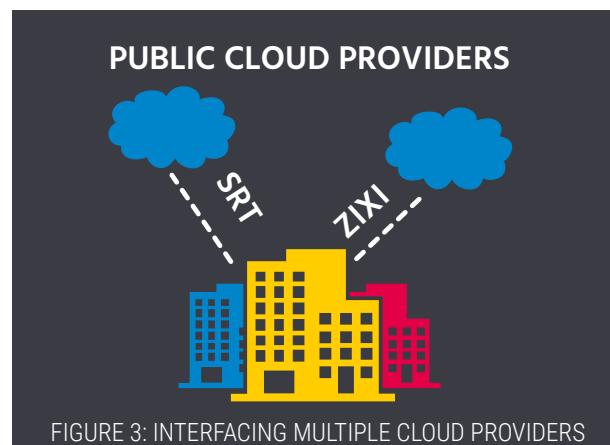
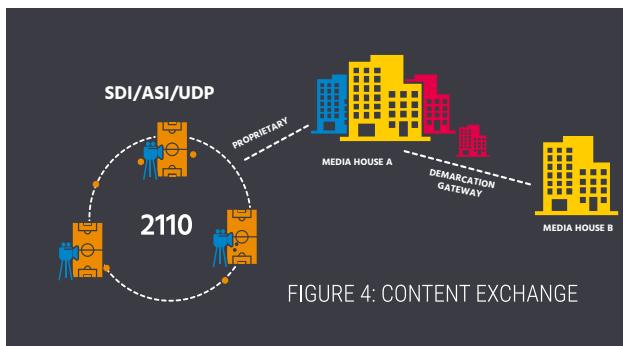


FIGURE 3: INTERFACING MULTIPLE CLOUD PROVIDERS

Looking at the two top cloud providers, they have today chosen different solutions for ingest. This is unfortunate because instead of unifying one common technology stack, it drives the market towards continued fragmentation.

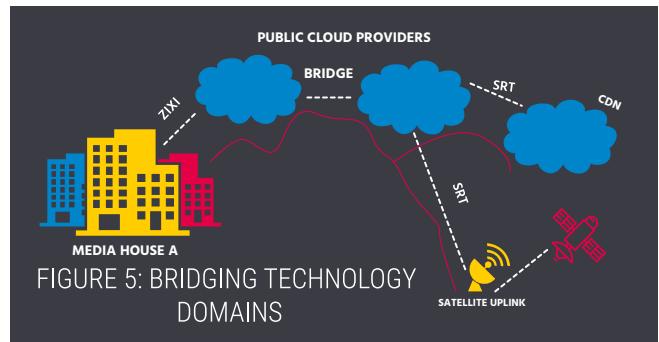
## X. Content exchange of live video

While slightly outside of the scope of this paper, content exchange is highly relevant mainly because much like cloud ingest, it requires a high degree of interoperability. For uncompressed media, the default course of action today is SDI, slowly being replaced by ST 2110 and in the interim ST 2022-6. While it could be argued that for compressed exchange, ST 2022-2, or VSFs TR-01 already provides handover functionality, that is only really applicable for ideal network environments, such as well-managed LANs.

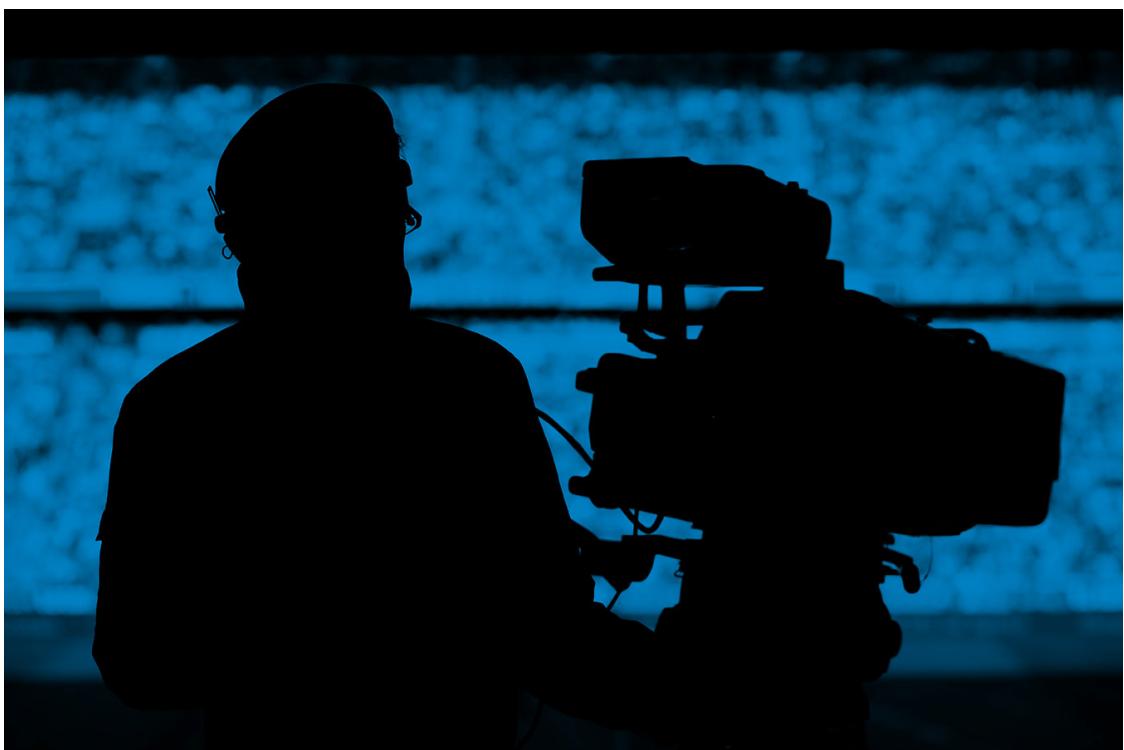


As soon as the network conditions require some kind of protection, costly dual box configurations start inserting itself into the network architecture.

Given that at least two of the three implementations discussed in this paper already boosts reasonably large ecosystems, any exchange between organizations is likely to be a combination of them. This does however open up for a critical question. Is it really enough to support just one of these retransmission implementations, or will media houses need to interwork with all of them?



As broadcasters need to interwork with multiple implementations to maximize their content reach, building solutions that can work across technology domains while still providing the same fundamental properties will be key.



## CONCLUSION

As retransmission technology continues to mature, large ecosystems have already established themselves in broadcasters' infrastructures.

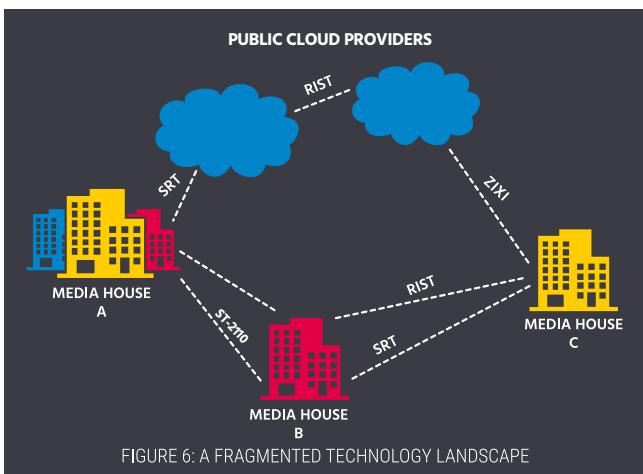


FIGURE 6: A FRAGMENTED TECHNOLOGY LANDSCAPE

While it is likely to assume that VSFs RIST will be a requirement from broadcasters going forward, it is still lagging behind in functionality compared to many of its' peers. Similar to what has happened in other technologies, we can expect standards, or TRs in this case, to act as a common interface for content exchange, while proprietary technology still has a place for niche use cases.

Still, let's not forget that most of the market is at this point is still not about content exchange and cloud ingest, but rather focused on contribution or distribution feeds within a single organization. Also here, RIST has a part to play as it makes it possible for broadcasters to employ dual vendor strategies.

Ultimately, it is reasonable to believe RIST, or any standards-based solution, will win this game in the long run, but given the massive footprints already claimed by a few ecosystems, this time is not likely to be any time soon.

For now, we need solutions, products and vendors that are flexible enough to work with more than one of these implementations. And we need products and solutions to bridge different technology domains in cases where two or more organizations wish to interconnect but are already invested in different primary retransmission technologies.

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