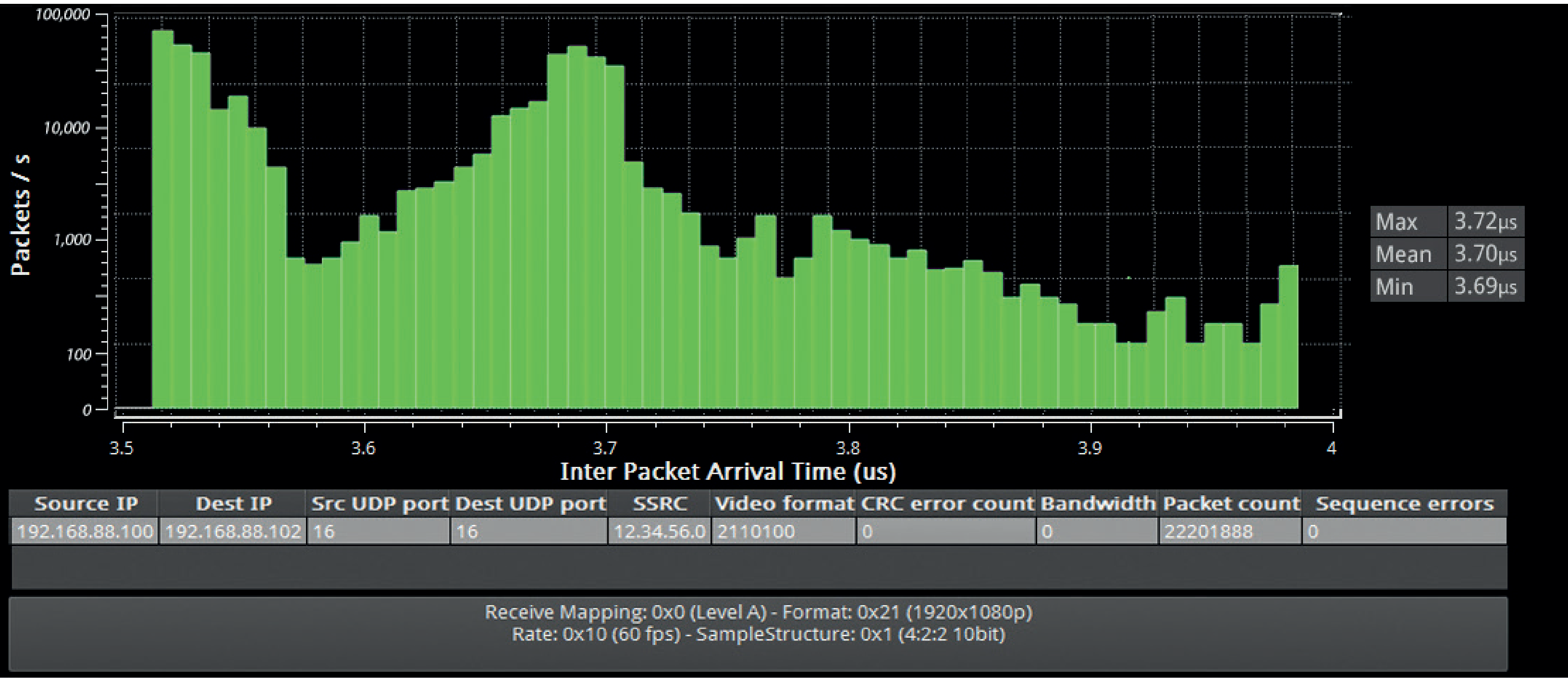


IP video network congestion and stress testing

Application Note

IP video network congestion and stress testing

Introduction

Migration towards SMPTE 2110 and SMPTE 2022-6 video networks for production and content delivery is picking up pace, as the advantages of IP versus traditional 'SDI over coaxial cable' carriage become more evident. The key drivers of IP include the economies of scale and speed of technology development that stem from the use of Commercial-off-the-Shelf (COTS) IT equipment, along with the introduction of more flexible and scalable business models based on virtualisation and cloud technologies.

However, this migration to IP video networks does present significant technical challenges for broadcast engineers. 'SDI over coaxial cable' was designed as a dedicated link for synchronous, point-to-point delivery of constant, high bitrate video. In contrast, IP infrastructures are typically asynchronous in nature, and this can present major issues for real-time video delivery, due to the occurrence of network congestion, latency, and Jitter. To address these issues, there's a real need for new types of IP signal generation, analysis and monitoring tools to diagnose operational video network issues, and stress test broadcast systems in advance.

Why video network congestion occurs

The inherent burstiness of IP networks makes them prone to packet congestion. Additionally, propagation delays are often introduced at the interfaces of video network routers, and these can also lead to congestion. Multi-hop networks – with multiple routers/switches between the data source and its intended destination – only result in a multiplying of this type of delay.

The delays caused by routers/switches can also be exacerbated in a multi-hop infrastructure by the different paths taken by IP signals across the infrastructure, which can cause further variations in network latency.

A key cause of congestion is an unmanaged, unexpected peak in multi–signal traffic in a network with insufficient bandwidth to handle it. A further minor contributor to network congestion is the additional overhead of network management traffic to oversee the routing of the video streams.

All these different sources of network congestion and latency will delay the arrival of video packets, and this can lead to significant Jitter problems. Ultimately, this Jitter can seriously impact the Quality of Service for broadcasters. Managing Jitter is particularly important in a low latency system with a required small receiver buffer size.

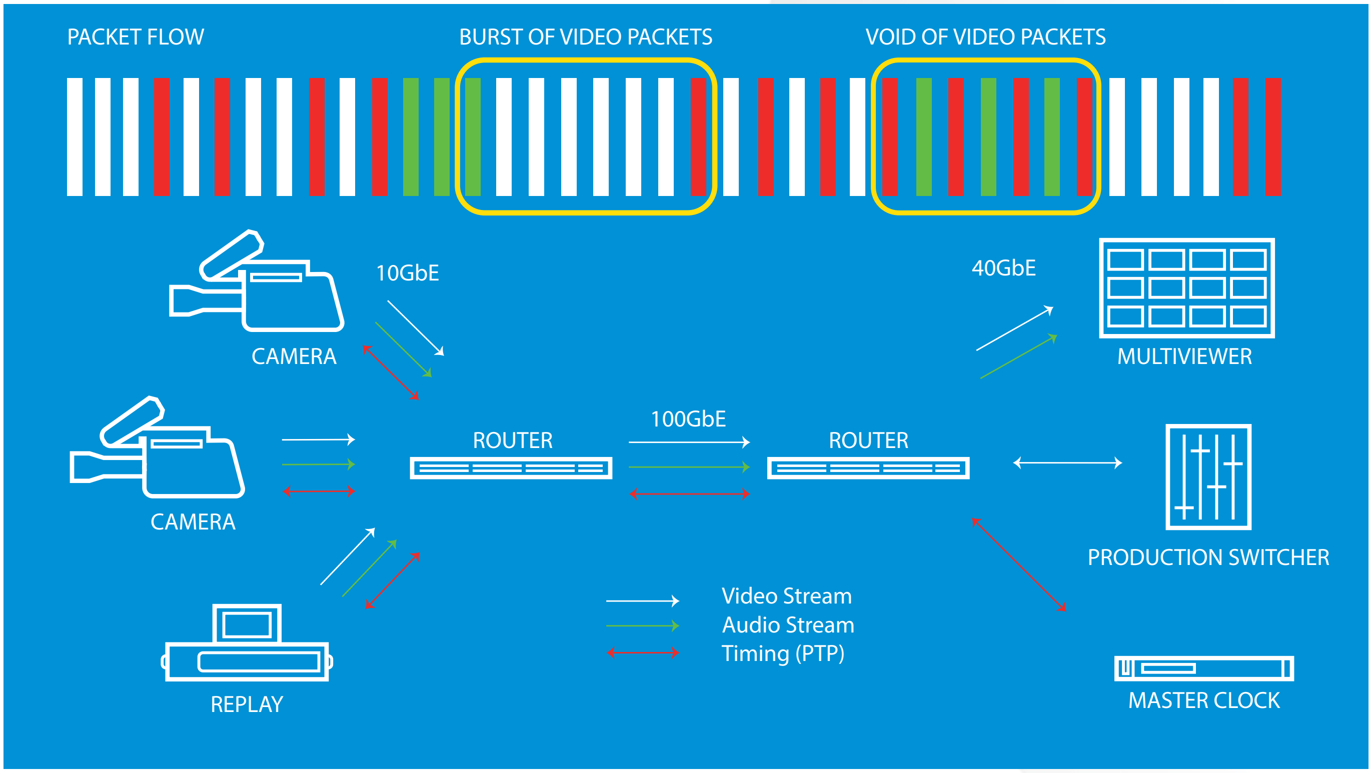
The problem of excessive Jitter

Jitter is a deviation in signal periodicity. In the case of an IP video signal, Jitter is a deviation from the expected packet arrival periodicity. Excessive deviations in Packet Interval Time (PIT) - also known as Inter Packet Arrival Time (IPAT) - can lead to packets being stalled, as well as packets being lost at the receiver.

In broadcast video networks, it is vital to ensure that excessive deviation past the expected interval is not occurring, as this risks stalling the signal (due to receiver de-jitter buffer underflow).

It's also important that not too many packets are arriving with smaller than expected intervals, so as to overflow the receiver de-jitter buffer, leading to packet loss.

In both cases, the video is impaired and, in extreme cases, the video signal will be lost. Hence, the ability to monitor and diagnose network congestion, and associated Jitter problems, is key to maintaining a healthy video network.



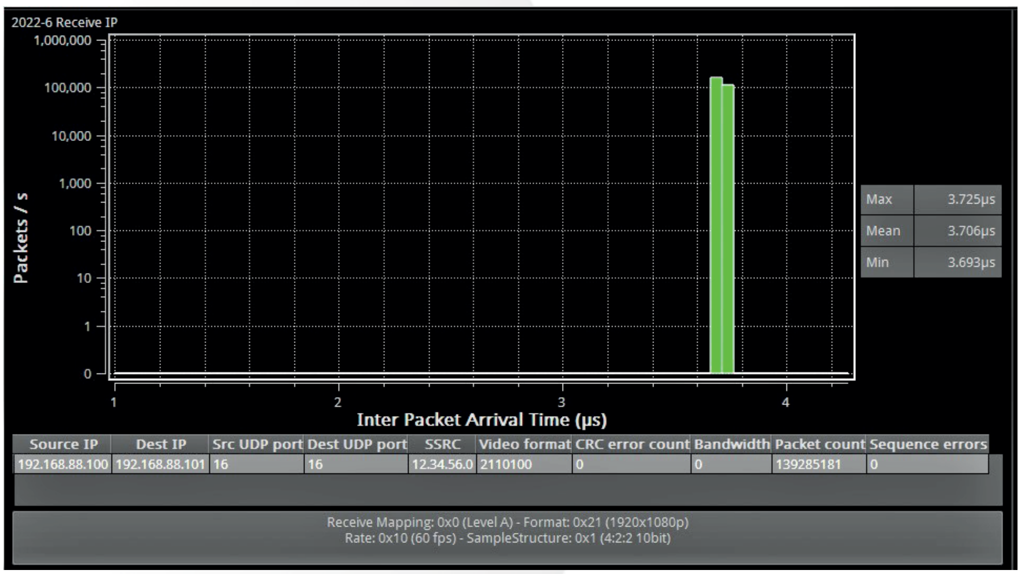
Typical video network packet flow with packet congestion

Congestion testing using *Packet Interval Timing (PIT)* analysis

How network congestion can be analysed with Packet Interval Timing (PIT)

Jitter can be measured by observing variations in the video packet arrival intervals (Packet Interval Times). Analysis of the inter packet arrival distribution of a video signal will provide an indication of its health, and give a warning of any broadcast critical network congestion.

Plotting a histogram of all the IPATs per second, gives a real-time view of how network congestion is affecting a video signal. It's also important to measure the IPAT mean, as well as minimum and maximum values, to provide instant network analysis.



Packet Interval Timing (PIT) analysis tool showing an idealised network without congestion

What characterises a good packet distribution?

In a 'perfect' network, a video signal would have constant periodicity, without Jitter, and all IPAT values would be the same. In a network with very low Jitter, you would expect to see a normal distribution, with the vast majority of IPAT values in and around the signal period (the expected interval arrival time).

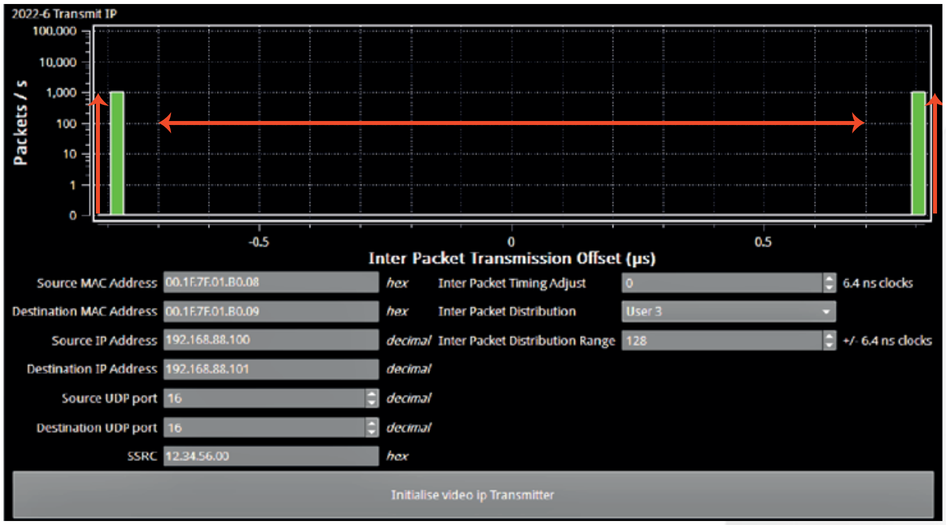
However, the reality of congestion in networks means that we expect to see a broader distribution of interval arrival times around the expected nominal value.

Hence, a healthy video signal will have a distribution peak centred around the expected IPAT. Due to the individual characteristics of a network, some significant Jitter might be tolerable, but a high occurrence of Jitter at the extremes would potentially lead to video signal impairment or loss.

What does a problematic packet distribution look like?

An impaired video signal will have a packet distribution characterised by some of the following factors:

- High occurrence of extremely long or short Inter Packet Arrival Times (IPATs)
- A distribution mean different from the expected signal period



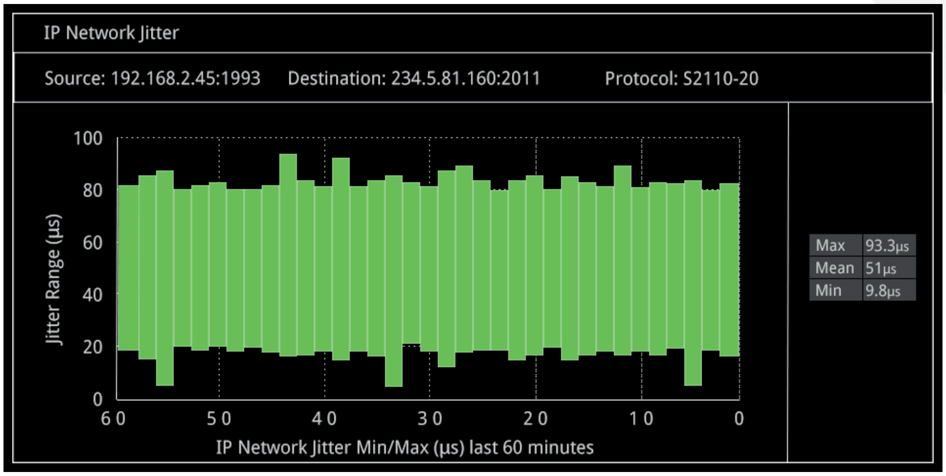
Histogram showing a less healthy distribution, with a significant occurrence of long IPATs

Monitoring congestion over time

Other tools can give us additional insight into how packets are arriving at the receive end. In addition to performing real-time Jitter measurements, it is also valuable to track PIT variance over time to gain a longer term monitoring perspective.

Logging this data can provide vital information on the health of a network. For instance, a deterioration could be indicated by increased maximum IPATs and a steadily rising mean.

A PIT Logging tool can also provide historical information on network congestion health at the time of an on-air incident.



PIT Logging tool showing accumulated max/min PITs for all packets plotted against time

Stress testing video networks using *Packet Profile Generator* tool

How video networks can be stress tested for vulnerability to congestion and Jitter

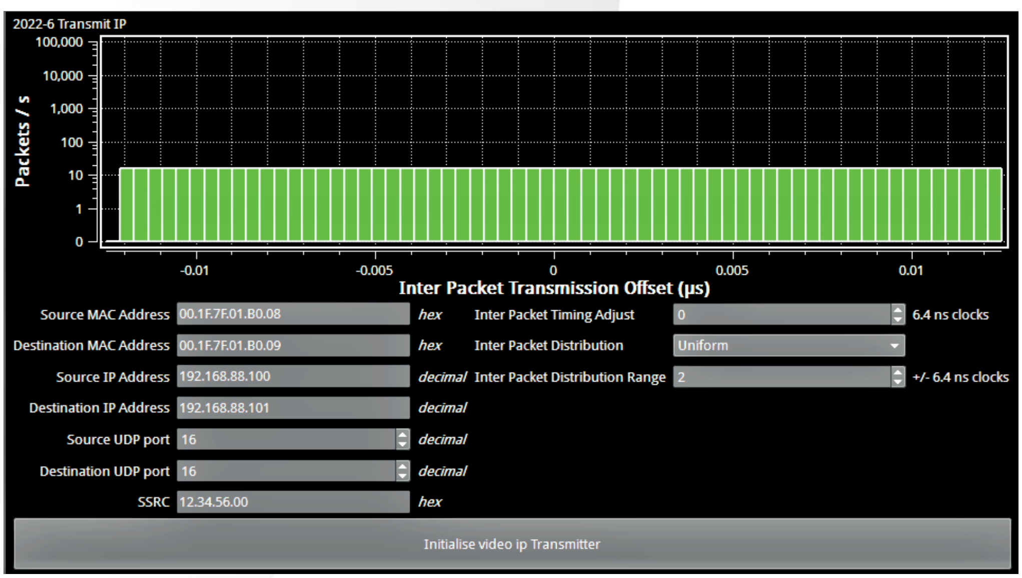
It's not enough to analyse a video network when there's a problem. Broadcasters need to stress test their facility as their IP network evolves, and new devices are added.

Before adding an IP video device to a network, such as a video router or playout server, it's important to stress test the response of the device to IP video signals transmitted under a variety of network conditions. It's essential to have a tool to flag up network congestion issues before they become a real problem.

Key questions for broadcast engineers to address include:

- How will the video network perform under congestion conditions?
- What is the tolerance of a new broadcast device to high amounts of Jitter?

These questions can be addressed using an IP signal generator tool with the ability to change transmission packet distribution profiles to simulate different congestion conditions in video networks.



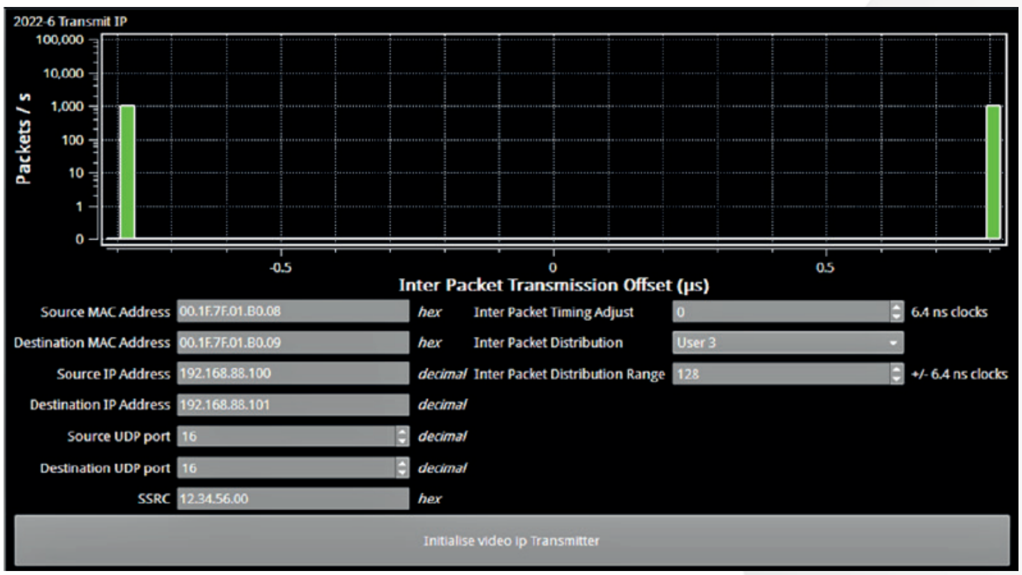
Packet Profile Generator tool for stress testing IP video networks

Using a *Packet Profile Generator* tool

A Packet Profile Generator tool displays a histogram showing the generated signal's Packet Interval Timing (PIT).

The timing can be adjusted to simulate network-introduced packet interval timing Jitter, and this allows for the careful creation of bespoke profiles. The ability to save network distribution profiles for future re-use is highly advantageous.

This type of IP video packet generation tool can be used in testing the impact of network infrastructure on IP stream transmission and reception. In conjunction with IP video packet analysis tools, this instrument provides a powerful capability for network stress testing and fault diagnosis.



The Packet Profile Generator's transmission profile can be varied to test networks

Conclusion

IP video networks have created a new set of test and measurement challenges for broadcast engineers, especially with respect to managing network congestion. However, new IP signal generation, analysis and monitoring tools are now available to enable engineers to better manage packet congestion, and thereby avoid serious Jitter issues, which can jeopardise broadcast Quality of Service.

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